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MASON & HANGER
SILAS MASON CO., INC.

AN ENGINEERING STUDY
FOR THE
REMOVAL AND DISPOSITION OF PCB CONTAMINATIOI
IN THE
WAUKEGAN HARBOR AND NORTH DITCH
AT
WAUKEGAN, ILLINOIS

FINAL REPORT

Submitted to:

United States Environmental Protection Agency
Region V
Chicago, Illinois
Contract No. 68-03-2647

Prepared By:

Mason & Hanger-Silas Mason Co., Inc.
Lexington Engineering Office
1500 West Main
Lexington, Kentucky 40505

MASON & HANGER-SILAS MASON CO. INC. SINCE 1827

January 1981

Duplicate

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AN ENGINEERING STUDY FOR THE REMOVAL
AND DISPOSITION OF PCB CONTAMINATION
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AT WAUKEGAN, ILLINOIS

January 29, 1981

FINAL REPORT

SECTION OF REPORT	ITEM
EXECUTIVE SUMMARY	Page ii, 7th line from bottom, capitalize Harbor.
Section 1	Page 1, bottom line, capitalize Ditch and Harbor. 9th line from bottom, capitalize Harbor.
Section 2	Page 6, bottom line, capitalize Lake. 8th, 9th and 13th lines from bottom, capitalize Ditch. Page 7, 23rd line from bottom, PCB should be PCBs. Page 10, 3rd line from top, capitalize Appendix. 9th line from bottom, insert comma after McLean. Page 11, 3rd and 15th lines from bottom, capitalize Appendix. Page 13, 4th line from top, small i in Ditch. 11th line from top, singular penetration. Page 19, 12th line from bottom, change average to averaged.
Section 3	Page 24, add PCB after 1 ppm and 17 ppm at center of page. 4th line from bottom, capitalize Lake. Page 28, 3rd line from top, capitalize Appendix. Page 29, 14th line from top, capitalize Appendix. 19th line from bottom of page, change "also" to "had previously". Page 31, 12th line from bottom, capitalize Appendix. Page 32, 6th line from bottom and 3rd line from top, capitalize Appendix. Page 37, 23rd line from bottom, capitalize Appendix. 6th line from bottom, add s to contain. 2nd line from bottom, change an to a. Page 39, top line, 3rd and 16th lines from top, capitalize Harbor. Page 42, 17th line, add (in front of formerly. 10th line from bottom, capitalize Chain, Custody.
Section 4	Page 45, 17th line from top, add s in Discharge.
Section 5	Page 54, 7th line from top, add period after Ltd. 9th line from top, delete the word are. Page 56, 8th line from bottom, correct spelling

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of obtained. Page 57, 11th line from top, correct spelling of Commercial. 13th line from top, change Mass. to Tenn. 12th line from bottom, change an to a. Page 58, 7th line from top, omit ! and comma from 1800°F. 5th line from top, omit comma from 1350°C. 11th line from top, omit comma from 1800°F. 18th line from bottom, correct spelling of discussed. Page 59, 2nd line from top, insert period after sediments. 8th line from top, correct spelling of approved.

Section 6	Page 65, 10th line from bottom, correct spelling of opposition. Page 68, top line, change Ill. to Illinois. 20th line from top, correct spelling of dredging. Page 69, capitalize Harbor in the following lines: 3rd, 5th, 8th, 12th, 13th and 15th lines from bottom. Page 70, capitalize Harbor in 2nd and 19th lines from top. Page 71, capitalize Harbor in the following lines: 14th, 16th, 21st, 23rd, 24th, 27th, 31st, 33rd and 37th lines from top. Page 73, 3rd line from top, correct spelling of residues.
Section 7	Page 75, 8th line from top, capitalize Crescent Ditch, Oval Lagoon. Page 77, 2nd line from top, capitalize Crescent Ditch. Page 84, capitalize Lagoon on the following lines: 14th, 15th, 19th, and 20th lines from top. Capitalize Crescent Ditch on 21st line from top. Page 85, capitalize Crescent Ditch on top line. Page 87, capitalize Appendix on top line. Page 88, capitalize Crescent Ditch in Item 3 and Oval Lagoon in Item 11. Page 90, capitalize Crescent Ditch in 4th line from top and in Items 2 and 9. Capitalize Oval Lagoon in 5th line from top and on bottom line. Page 91, capitalize Oval Lagoon in first Item 7. Page 93, 2nd line from bottom, capitalize Crescent Ditch, Oval Lagoon. Page 94, capitalize Crescent Ditch, Oval Lagoon on top line.
Section 8	Page 105, 3rd line in Item 8.3, add s to show. 14th line from bottom, add s to recommend. Page 113, 9th line from top, change is to are and capitalize Appendix. Page 117, 10th line from bottom, change concentrating to concentrations. Page 118, 7th line from top, delete s from includes. Capitalize Harbor in Item 7. Page 119, capitalize Harbor in Item 15. Page

122, capitalize Harbor in Item 15. Page 125, capitalize Harbor in Item 15.

Section 9

Page 134, capitalize Appendix in 15th line from bottom. Add s to estimate in 12th line from bottom. Page 137, correct spelling of wells in 9th line from top. Page 140, add s to include in 16th line from top. Page 142, change Crescent Lagoon to Crescent Ditch in 15th line from bottom. Page 144, correct spelling of permeability in 5th line from top. Add (Typical regional value) after the 0.5 value for Porosity of clay. Add (Developed from Darcey's Law) after the equation V = KG/P. Add = 29 years at bottom of page after the Time Calculation. Page 145, at top of page, 2.84×10^{-5} ft./day should be 2.84×10^{-4} ft./day, 3,420 Ft.^{3}/yr. should be 34,200 Ft.^{3}/yr, 62.5 lb/ft. should be 62.5 lb/ft.^{3}. The amount calculation should be: Amount = $34,200 \times 100 \times 10^{-9} \times 62.5$, Amount = 0.2 lb/yr. PCB. Change 0.02 to 0.2 in 2nd and 3rd paragraphs. Page 145 Second Paragraph: Change "0.006 lbs of PCBs per year" to "0.06 lbs of PCBs per year". Correct spelling of status in 2nd line of 3rd paragraph.

Section 10

Page 148, delete s from includes in 16th line from bottom. Correct spelling of slope in 8th line from bottom. Page 149, add the following sentence at the end of Section 10.2: Estimated costs for restoration of the OMC vacant land are presented in Section 8.9 (page 128 of this report) and these costs are to be added to the above estimated figures.

AN ENGINEERING STUDY

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1500 West Main
Lexington, Kentucky 40505

January 1981

EXECUTIVE SUMMARY

Polychlorinated biphenyls (PCBs) have been found in Waukegan Harbor and in land owned by Outboard Marine Corporation (OMC) near North Ditch, a small tributary of Lake Michigan at Waukegan, Illinois. The existence of PCBs has been confirmed by various public and private organizations as the result of sampling and analysis of water, soils, and sediment during the period June 1976 through November 1980. Localized concentrations of PCB exceeding 30 percent (dry weight basis) have been found in soils or sediments at former OMC discharge points. The discharge points were in the crescent ditch portion of North Ditch near the OMC Die Storage Area and in Slip #3 of Waukegan Harbor. Soil and sediment sampling has confirmed that PCBs have penetrated into the sand at the outfalls and have pooled on top of the underlying silty-clay layer 18 to 23 feet below the surface. There is some penetration of PCBs into the clay in these areas. In addition, PCBs have spread laterally from the outfalls, contaminating the loose soft top sediments throughout Waukegan Harbor and in North Ditch. Some land areas on OMC property just south of the North Ditch and several thousand feet from the original dishcarge point have PCB concentrations in the soil which exceed one percent.

Based upon data gathered by others and by independent sampling, Mason & Hanger-Silas Mason Co., Inc., Lexington, Kentucky, estimates that approximately 168,000 cubic yards of Waukegan Harbor bottom sediments would have to be removed to clean up areas of contamination exceeding 10 parts per million PCB. In addition, approximately 160,000 cubic yards of North Ditch soils would have to be excavated to remove contaminated material containing over 50 ppm PCBs. Roughly one million pounds of PCB are estimated to exist in contaminated materials within Waukegan Harbor and North Ditch combined.

Dredging appears to be the most viable option for removal of the contaminated Waukegan Harbor sediments. Temporary storage of the dredge spoils and associated water generated during dredging is lagoon(s) constructed on vacant OMC property adjacent to Waukegan Harbor affords the most economical solution for dewatering of these dredged materials. After settling and dewatering of lagoon sediments, the excess water would be treated (using polymers, filters, and carbon filters) to remove PCBs to levels less than one part per billion before returning to Waukegan Harbor. In addition, a localized area of deep contamination in Slip #3 (currently estimated at 800 to 2000 cubic yards) would have to be excavated. Preliminary budgeting estimates (December 1980 dollars) of costs for removing varying amounts of harbor sediment contamination, including dredging, lagoon construction and water treatment are listed below. These costs do not include (1) temporary relocation of OMC intake during dredging and excavation of Slip #3, (2) loading the dewatered sediments into trucks, (3) for restoring the land to its original function, or (4) for transporting of the contaminated materials to the final disposal site and (5) any final disposal costs at the site.

Removal Level	Cu. Yds. Removed*	Estimated Cost
Over 500 ppm	9,000	$2,800,000
Over 50 ppm	47,000	$5,100,000
Over 10 ppm	168,000	$8,400,000

* Includes removal of approximately 2000 cubic yards of sand and clay beneath the OMC outfall (now abandoned) in Slip #3.

Contaminated North Ditch soils and North Ditch sediments should be excavated and placed in a secure landfill constructed in accordance with applicable government regulations. Before any excavation is done, the North Ditch water should be bypassed around the more highly-contaminated areas. Then excavation of soils in a dewatered condition using slurry walls and well pointing should be performed. The total project cost, including the North Ditch bypass, excavating 160,000 cubic yards of contaminated material and placing in trucks, treatment of contaminated water, and restoring the land to its original function is estimated to be about $11,000,000.

Costs for landfill disposal of 367,000 cubic yards of contaminated soils and sediments are expected to be almost $20,000,000 if disposed at the Browning-Ferris Industries landfill site at Zion, Illinois. This quantity includes 168,000 cubic yards of Waukegan Harbor sediment, 160,000 cubic yards of North Ditch material, and possibly 39,000 cubic yards of additional material. The additional contaminated material includes (1) contaminated lagoon liner material, (2) sand from sand piles now on vacant OMC property used for lagoon dewatering, (3) material spread on top of removed contaminated sediments and soils to prevent volatilization, and (4) used filter media and spent carbon. The additional material should, of course, be kept to a minimum consistent with other objectives.

If the existing OMC Parking Lot can be approved for an "on-site" disposal area, the cost would be about $10,000,000. Either site will have to be permitted to receive PCB contaminated materials and developed according to applicable governmental regulations.

PCB contamination disposal alternatives, such as "in-place" storage on OMC property are discussed in this report.

A restoration project involving this quantity of PCB contamination has never been performed in the United States. Therefore cost estimates are very difficult to develop. Costs are affected by environmental safeguards demanded by the public and governmental agencies and by the impact to the parties inconvenienced by the corrective action recommended in this report.

Removal of contaminated material should begin as soon as possible to avoid further spread of PCBs into the environment.

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1.0 INTRODUCTION

The U. S. Environmental Protection Agency contracted with Mason & Hanger-Silas Mason Co., Inc., Lexington, Kentucky, to perform an engineering study to recommend a solution for removing, fixing, or otherwise treating the PCB contaminated soils and sediments located in and near Waukegan Harbor, Waukegan, Illinois (see Figure 1). The study recommends removal, storage and treatment techniques and estimated associated costs for the contaminated soils, sediments and associated waters. Mason & Hanger, in turn, has subcontracted with Warzyn Engineering, Inc., Madison, Wisconsin, geotechnical work and a study concerning final disposal of the contaminated materials. Raltech Scientific Services, Madison, Wisconsin, has a subcontract to perform analyses to determine PCB content of samples furnished by Warzyn and Mason & Hanger.

1.1 Background

In 1976, the Johnson Motors Division of the Outboard Marine Corporation (OMC) in Waukegan, Illinois was discovered discharging polychlorinated biphenyls (PCBs) to a ditch (hereinafter referred to as the North Ditch) located on their property and to Slip #3 of Waukegan Harbor. There were two outfalls believed to be discharging to the ditch and one discharging to the harbor (see Figure 2). Records of the company indicate that about 9 million pounds of PCBs were purchased from the Monsanto Company during the period from at least 1959 to 1971 for use as hydraulic fluids in die casting machines and related equipment. It is believed that 10 to 20 percent of these PCBs were discharged to the slip and ditch.

Sampling has been performed by numerous organizations which verifies the existence of this contamination. These organizations include the U.S. Environmental Protection Agency, the Illinois Environmental Protection Agency, the Environmental Control Technology Corporation (ENCOTEC), consultants to OMC, Warzyn Engineering, Inc., and others. Organizations performing analyses which verify the existence of PCB contamination include the U.S. Environmental Protection Agency, the Illinois Environmental Protection Agency, Environmental Research Group (ERG), Raltech Scientific Services, Inc., and others. Localized concentrations in excess of 30 percent PCB by weight in the North Ditch and 50 percent PCB by weight in the harbor have been found (dry weight basis).

1.2 Characteristics of Polychlorinated Biphenyls

PCBs are compounds formed by the chlorination of the biphenyl molecule. There are a large number (greater than 150 have been identified) of different molecular compounds called isomers which can be formed from this reaction. PCBs used by industry are typically a mixture of these isomers. In the United States, PCBs were sold by Monsanto Corporation under the trade name Aroclor. The PCBs discovered in the contamination of the ditch and harbor have been found to have

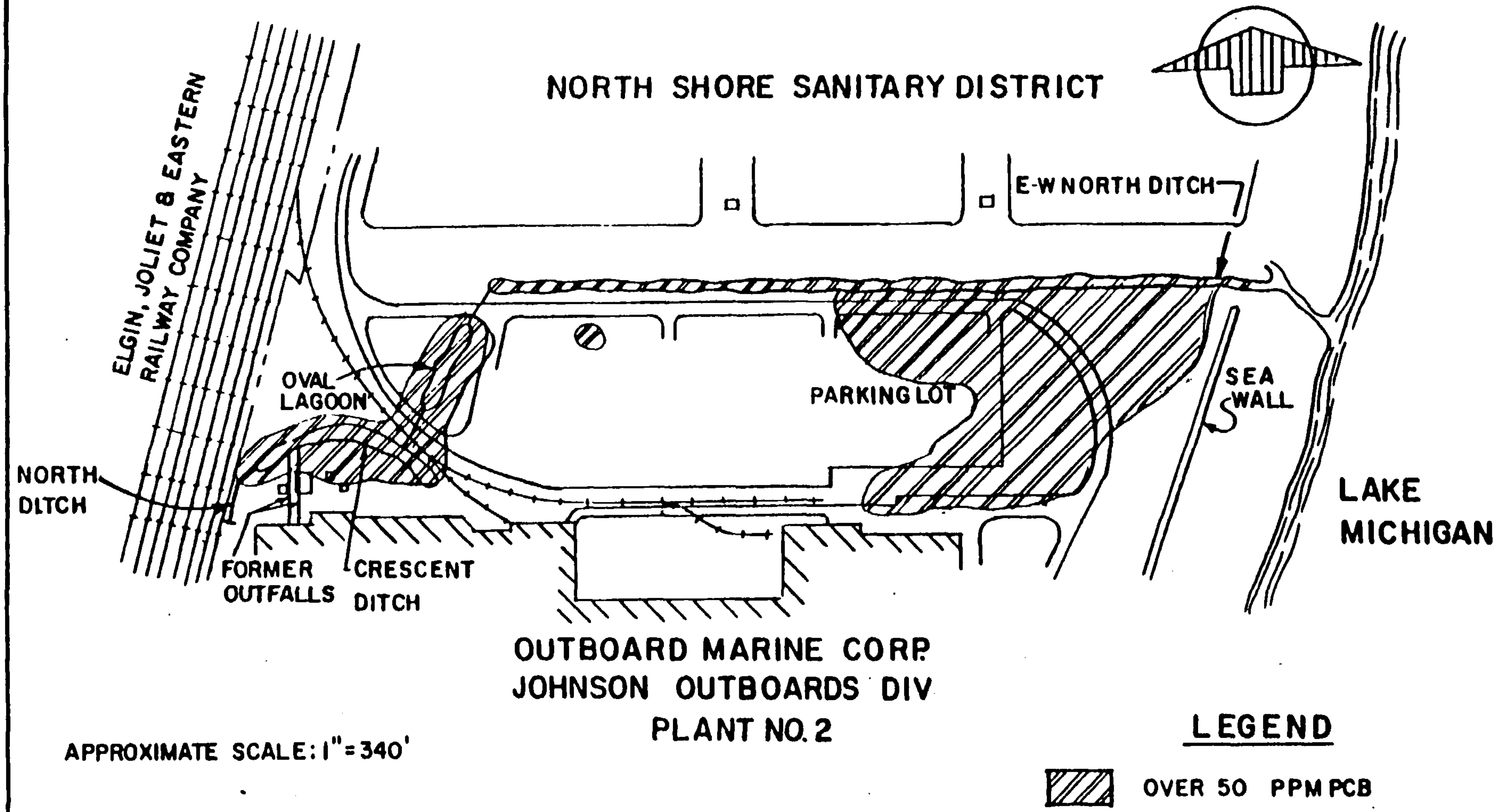


FIGURE 4

NORTH DITCH AREA

EXTENT OF PCB CONTAMINATION

OVER 50 PPM

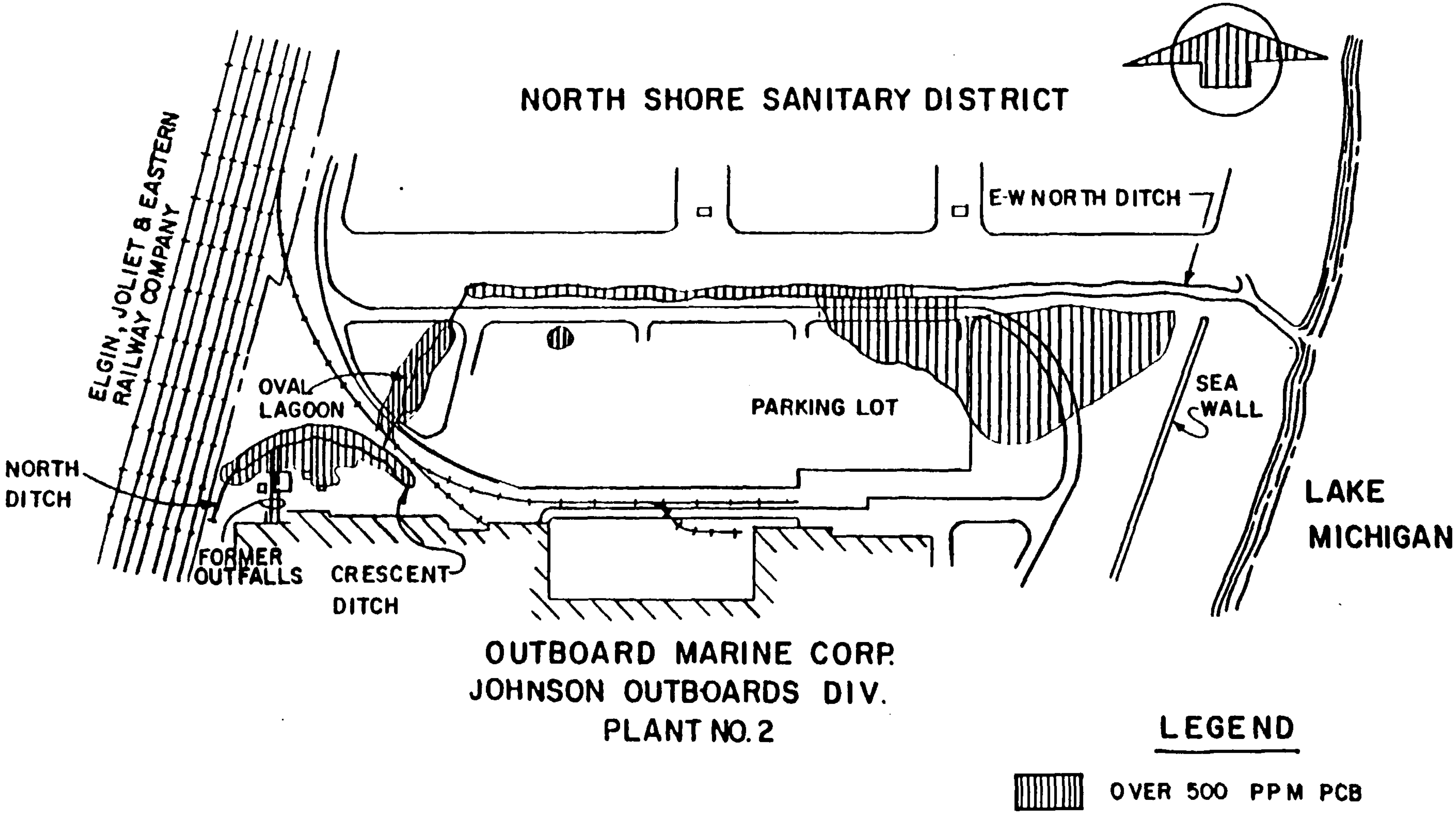
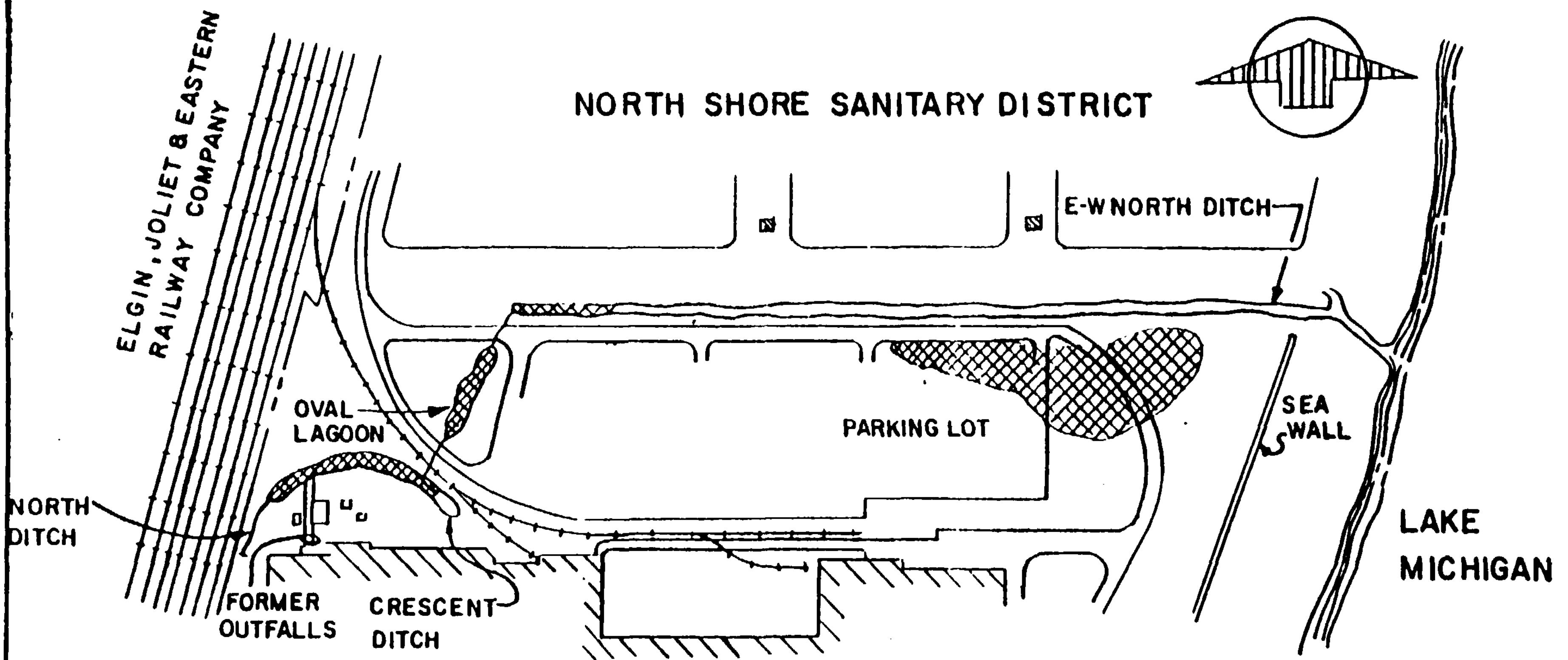


FIGURE 5

NORTH DITCH AREA

EXTENT OF PCB CONTAMINATION

OVER 500 PPM



OUTBOARD MARINE CORP.
JOHNSON OUTBOARDS DIV.
PLAN NO. 2

LEGEND

OVER 5000 PPM PCB

FIGURE 6
NORTH DITCH AREA
EXTENT OF PCB CONTAMINATION
OVER 5000 PPM

Referring to Figure 4, the boundaries of possible contamination greater than 50 ppm are listed below:

Description	Estimated Total Cubic Yardage
Crescent Ditch	
60' wide, 520' long and 25' deep	28,900
Die Storage Area (Land just south of Cresent Ditch)	
21,000 square feet 3' average depth	2,300

Description	Estimated Total Cubic Yardage
Oval Lagoon	
7,500 square feet to 16 feet deep average	14,600
34,500 square feet to 8 feet deep average	
North Ditch (E-W portion)	
25 feet wide 1900 feet long, 4 feet deep average	7,000
OMC land south of North Ditch (incl. parking lot)	
220,000 square feet, 2 to 12 feet deep	68,000
Deep contamination near boring B15:	
21,000 square feet to 30 feet	
plus 33,000 square feet 5 to 30 feet	37,000
Total Cubic Yardage	157,800 (say 160,000)

The 160,000 cubic yard total is calculated on the basis of the volume of contaminated soil greater than 50 ppm which would have to be removed during an excavation project. This means all soils down to the deepest area of 50 ppm contamination are counted in the 160,000 cubic yard total even though upper layers may contain less than 50 ppm. This means, for example, that the soils at boring location B8 4 feet 3 inches deep with 11.8 ppm PCB are included in the "above 50 ppm category" because soils at 9 inches and 9 feet 3 inches contain over 50 ppm.

Not enough information on exact locations of PCB contamination is known as to how deep the soils must be removed in the Oval Lagoon and Crescent Ditch. If, for example, everything in the Crescent Ditch is removed to an average depth of eight feet, and an area 60 feet by 120 feet is excavated to a depth of 8 to 25 feet (16.5 feet average), then 11,500 cubic yards rather than 28,900 cubic yards should be removed. If, for example, contamination in the Oval Lagoon extends only to a depth of 8 feet, then about 6,000 cubic yards rather than 14,600 cubic yards need to be removed. The total would be about 130,000 cubic yards rather than 160,000 cubic yards. Further deep test borings would be required in the Oval Lagoon and Crescent Ditch in order to more exactly define the quantities of contaminated material to be removed. Additional borings are also recommended in the parking lot in order to define the boundaries of contamination.

The total quantity (pounds) of PCB present is more difficult to estimate than the volume (cubic yardage) of contaminated material. Robert Thomann of Hydroqual, Inc., (formerly Hydroscience, Inc.) under U.S. EPA contract to estimate the degree of environmental exposure of PCBs at Waukegan, has suggested that Mason & Hanger calculate North Ditch sediment contamination separate from soil contamination. The sediment contamination is represented by sediment core samples SC-1 through SC-20 (identified in the pocket insert location map) and the U.S. EPA, Ill. EPA and ENCOTEC samples discussed earlier. The pounds of PCB are calculated as follows:

$$\text{Pounds of PCB} = CSYd\ (27)\ (10)^{-8}$$

Where C = overage concentration of PCB in ppm (dry weight basis)
S = percent solids (varies from 75 to 92% for most samples)
Y = cubic yardage
d = density (110 lbs per cubic foot for wet sand)

The sediment core samples SC-1 through SC-20 (samples SC1, SC3, SC5 and SC11B not yet analyzed by Raltech) yielded the following average concentrations and pounds of PCB:

Location:	Crescent Ditch	Oval Lagoon		North Ditch (E-W)
		NE Section	SW Section	
Area, sq. ft.	8,060	4,455	1,584	32,900
Depth, ft.	6.5	5	5	6
Cubic yardage	1,940	825	293	7,311
Sediment Cores	SC13 thru SC20	SC7, SC8, SC10	SC9, SC12	SC2, SC4, SC6
Avg. PCB (wet basis) ppm	9,230	6,626	43,589	101
Pounds of PCB	53,192	16,235	37,975	2,193

Total sediment quantity of PCB calculates to be 107,402 pounds based on this dat

A very different estimate is obtained if the earlier U.S. EPA, Ill. EPA and ENCOTEC sediment core samples are average (ignoring U.S. EPA surface grab samples);

Location:	Crescent Ditch	Oval Lagoon	North Ditch (E-W)
Area, sq. ft.	8,060	6,039	32,900
Depth, ft.	6.5	5	6
Cubic yardage	1,940	1,118	7,311
Avg. PCB (Dry basis) ppm	65,667	32,749	350
Avg. PCB (wet basis) ppm	54,832	27,343	293
Pounds of PCB	315,990	90,283	6,352

Total sediment quantity of PCB calculates to be 412,625 pounds based on earlier data

Robert Thomann, under U.S. EPA contract, has independently estimated a total of 253,000 pounds of PCB in the North Ditch sediments (using both the SC1 thru SC20 data completed as of December 1980 and the earlier EPA and ENCOTEC data). Thomann estimates a 68 percent confidence of 121,000 to 1,800,000 pounds of PCB in the North Ditch sediments. The average of Mason & Hanger estimates calculated from the two sets of data is 261,000 pounds which agrees closely with Thomann's best estimate of 253,000 pounds.

Table 1 represents an attempt to estimate the quantity of PCBs in the North Ditch area including land south of North Ditch based on all information obtained to date. A total of about 775,000 pounds of PCB is estimated, not counting PCBs below 5 feet in the Oval Lagoon (no data). The calculation assumes a certain configuration for PCBs in the Crescent Ditch especially below 6 feet deep and in the parking lot. Mason & Hanger is of the opinion that 775,000 pounds is a reasonable order of magnitude, with a possible low number of about 500,000 pounds and a high number of 1,500,000 pounds.

The boundary of contamination cannot be determined on the basis of the widely-spaced core borings. Furthermore, the core borings themselves generally show an askewed distribution of PCBs with respect to depth. Robert Thomann has suggested using geometric means rather than arithmetic averages as a method of tempering the data to avoid giving too much weight to a few samples of high concentration. The geometric means would result in a lower quantity of PCB than the arithmetic average.

Any calculation estimating the pounds of PCB depends upon the assumed boundary of contamination and how the core borings are grouped and averaged.

TABLE 1

AN ESTIMATE OF EXTENT OF PCB CONTAMINATION IN NORTH DITCH SOILS

Location	Calculated Avg. PCB Conc.	Calculated Pounds of PCB
1. Crescent Ditch		
Ditch sediments to 6.5 feet depth	38,360	184,591
Ditch soils, 6.5 to 25 feet depth, 13 feet wide, center 275' long portion near B32	31,073	183,658
Ditch soils, 6.5 to 25 feet depth, 13 feet wide, 340 foot section at two ends	4,714	34,448
Soil surround ditch, 122,324 cubic feet	90	1,012
Total Crescent Ditch		403,709
2. Die Storage Area		
21,000 square feet to 4'3" depth (soils)	242	1,992
21,000 square feet 4'3" to 24'3" (soils)	1	41
Total Die Storage Area		2,033
3. Oval Lagoon		
Lagoon sediments 5 feet depth	26,207	72,247
Lagoon soils 5 feet to 27 feet depth	No data	Unknown
Soil surrounding Oval Lagoon, 209,250 cubic feet	688	13,223
Total Oval Lagoon		85,470 plus
4. North Ditch (E-W Portion)		
Sediments to 6 feet deep	235	4,273

5. Parking Lot (considered to be soils)

Bore Hole #16, 300 cubic yards	1,375	1,023
Bore Hole B8: 120' dia. circle 9'3" deep	7,897	75,881
Bore Hole B4, B5, #10, #12; 31,782 sq ft, 4' deep	900	10,513
Bore Hole B12, B13; 46,240 square feet, 3' deep	120	1,529
Bore Hole B9: 23,791 sq. ft. 9.5' deep	82	3,778
Bore Hole B18: 20,000 sq. ft., 3' deep	17	94
Bore Holes #26, #25, #27, #2, #2A: 58,812 sq. ft. 5' deep	6,069	163,920
Bore Hole B15, 21,120 sq. ft. 30 feet deep	360	20,950
Total Parking Lot		277,688
Total Sediments items 1 thru 5		261,111
Total Soils items 1 thru 5		512,062
Overall Totals		773,173
	(Say	775,000 pounds)

The above calculation of 775,000 pounds of PCB is based on one interpretation of the data. Depending upon how the PCB concentrations are averaged and where boundary lines are drawn, estimate of anywhere from about 500,000 pounds to 1,500,000 pounds of PCB can be obtained. The distinction between soils and sediments at 5 to 6.5 feet deep in the Crescent Ditch, Oval Lagoon, and North Ditch is arbitrary.

2.3 Summary of Estimates of PCBs in North Ditch Area

2.3.1 Total Cubic Yards Which Would Have To Be Removed Over 50 ppm PCB

Crescent Lagoon Area	28,900
Die Storage Area Surface Contamination	2,300
Oval Lagoon Area	14,600
North Ditch (E-W Portion)	7,000
Parking Lot and Adjacent Land	105,000
TOTAL	157,800 cy
	(say 160,000 cy)

2.3.2 Total Pounds of PCB

Crescent Lagoon Area	404,000
Die Storage Area Surface Contamination	2,000
Oval Lagoon Area (excluding below 7')	85,000
North Ditch (E-W Portion)	4,000
Parking Lot	278,000
Amount below 7" in Oval Lagoon	Unknown
TOTAL	773,000 lbs.
	(say 775,000 lbs.)

2.3.3 Degree of Variance

In as much as the calculated quantities of materials to be removed which contain 50 ppm or above and the calculated quantity of PCB in these materials are based on certain assumptions, it is prudent to state that the quantity of material to be excavated could vary from the 160,000 cy estimate and the total pounds of PCBs could range from 500,000 to 1,500,000 pounds.

3.0 EXTENT OF PCB CONTAMINATION IN WAUKEGAN HARBOR

3.1 General Description of Waukegan Harbor

Waukegan Harbor is located on the west shore of Lake Michigan at Waukegan, 36 miles north of Chicago and approximately 10 miles south of the Wisconsin border. Waukegan, a city of 65,259 people (1970 census), encircles the irregular-shaped harbor. It is a major center for charter boat sports fishing and the principal pleasure boat harbor north of Chicago.

The area of the harbor exclusive of the mouth is approximately 37 acres. Water depths vary from 14 to 25 feet with some shallower spots near boat launching locations at the S-W end and in the far upper reaches of Slip #3. The depth at any one location varies with time depending upon (1) degree of siltation and whether the area has been dredged, (2) mean lake level, and (3) local seiches due to storms, wind shifts or other causes.

Historically, the U. S. Army Corps of Engineers has dredged an average of 30,000 cubic yards per year of sediments near the main entrance channel using mostly dipper dredges. No dredging has taken place within the harbor since PCB contamination was discovered in 1976; spoils from the last dredging (1974) were placed in mounds up to 14 feet high located on vacant land owned by Outboard Marine Corporation bordering the northwest portion of Waukegan Harbor. The mounds are composed of sand. The sand is owned by Waukegan Excavating Company. The U. S. Environmental Protection Agency reports that a very large portion of the sand contains less than 1 ppm. However, there are very localized areas of high concentration. The highest concentration reported was 17 ppm. Earlier dredge spoils were dumped into Lake Michigan. Falcon Marine reports that Slip #3 has not been dredged since about 1950 and that the upper portion of the harbor was last dredged about 1957. Slip #1 was widened and dredged in 1960. Slip #2, formerly located at National Gypsum, was closed about 1957.

Figure 2 illustrates the shape of Waukegan Harbor and the relative location of major businesses. Of particular interest is (1) the City of Waukegan Filtration Plant, which may at times use Waukegan Harbor as partial city water supply; (2) Falcon Marine; (3) Johnson Outboard, a division of Outboard Marine Corporation; (4) vacant land now owned by Outboard Marine Corporation that was the former site of the Chevrolet Saginaw Grey Iron Foundry; (5) Larsen Marine located at Slip #3; (6) Outboard Marine Corporation water intake and discharge points; (7) National Gypsum Co., which receives gypsum in large boats at Slip #1 and (8) Waukegan Port District. Numerous pleasure craft use docks located at Waukegan Port District. Pleasure craft also use docks owned by Larsen Marine in Slip #3.

Outboard Marine Corporation currently withdraws roughly one million gallons of water per day from Slip #3 for once-through cooling, returning at least 150,000 gpd to North Ditch and the remainder back to the Lake via a direct discharge to the lake. The Outboard Marine Corporation outfall shown in Figure 2 was the point of discharge of PCBs into Waukegan Harbor. This outfall was sealed in 1976. The OMC vacant land is the only undeveloped site bordering Waukegan Harbor.

Steel sheet piling borders the entire harbor except the boat launching areas at the Waukegan Port District and the retaining wall towards the harbor mouth. Some of the piling is 25 foot lengths and extends 3 or 4 feet above the harbor water level. There are some shorter piling lengths including some 20 foot piling at the upper portions of Slip #3. The piling was placed in the harbor at varying times from the 1920's to 1960. The piling bordering much of the vacant OMC property at the NW corner of the harbor is currently in bad condition. It is suspected that some have separated from the concrete wall and the pile tips are exposed.

A red marker currently exists at Falcon Marine at elevation 583.37 feet referenced to low water datum, Fathers Point, Quebec. Normally, the harbor water level ranges from 578 to 580 feet, but Falcon Marine reports water level changes as much as four feet within a few hours during a seiche.

3.2 Contamination in Waukegan Harbor

3.2.1 Background Information Concerning Discharges

Between 1959 and 1971, Outboard Marine Corporation purchased approximately 9 million pounds of PCBs from Monsanto (probably as Aroclor 1242 and 1248) for use in their aluminum die cast machines as a hydraulic fluid. Outboard Marine Corporation has reported in a letter to U.S. EPA Region V that possibly as much as 10 to 15% of the total PCB material purchased could have escaped and been discharged via floor drains from the leaking machines into Waukegan Harbor and North Ditch.

From 1971 through 1976, OMC is believed to have started replacing PCB fluids with non-PCB fluids in their die cast machines, but residual PCBs in lines and in die cast machines continued to leak into the plant outfalls. The PCB contamination at OMC was brought to the attention of EPA in 1976; at that time EPA estimated that OMC was still discharging on the order of 10 pounds per day of PCB. The OMC outfalls were then sealed off.

Based on documents obtained in discovery during the lawsuit, Outboard Marine Corporation is believed to have discharged PCBs in the mid 1950s. A phosphate ester product containing some PCBs was purchased and used during the period from 1951 to 1959.

Some of the PCB material used and discharged remains in Waukegan Harbor and North Ditch. The remainder has been carried out into Lake Michigan or has evaporated into the air. Hydroscience, Inc., under subcontract to EPA Region V, estimated that 7500 pounds per year average (possibly up to 15,000 pounds of PCB per year average) reached Lake Michigan from Waukegan Harbor and North Ditch combined during the period when OMC was discharging PCBs. Current (1980) transport of PCBs into Lake Michigan from residuals left in Waukegan Harbor appears to be roughly 20 pounds per year. These numbers developed by Hydroscience, Inc. are preliminary estimates and subject to further revision.

The major hazard of PCBs in Waukegan Harbor is that measurements (by EPA and others) show fish in the harbor will accumulate

PCBs well in excess of current level of 5 ppm and the proposed level of 2 ppm established by the Food and Drug Administration. The fish retain much of their PCBs when they migrate out of the harbor to other portions of Lake Michigan.

3.2.2 Review of Previous Studies

3.2.2.1 Illinois EPA Core Samples

Preliminary grab samples collected May 12 and June 9, 1976 by the U.S. EPA demonstrated that at least the uppermost layer of Waukegan Harbor bottom sediments were heavily contaminated with PCB. When the results became known, the Illinois EPA collected sediment core samples using a split spoon assembly at nine harbor locations. Concentrations of PCB in excess of 100,000 ppm were found in Slip #3 near the OMC outfall. Analyses results are in the appendix.

3.2.2.2 Environmental Control Technology Corporation (ENCOTEC)

ENCOTEC, under contract to Outboard Marine Corporation, collected (1) Waukegan Harbor and Lake Michigan water samples, (2) North Ditch sediment core samples, and (3) Waukegan Harbor bottom sediment core samples during winter and spring 1977. The PCB analysis results were furnished to the U.S. EPA, including 15 Waukegan Harbor sediment core samples collected in April 1977. ENCOTEC used 6.7 cm OD stainless steel thin walled tubes assembled as open-ended Shelby tubes, and then pressed and hammered to prescribed harbor depths. An 80 percent recovery criterion was considered as the lower limit of acceptability. Detailed boring logs were kept, the borings being made to the underlying hard clay layer. Each core (some samples were collected to a depth of 9 feet) was sectioned into one foot segments and analyzed for PCB.

ENCOTEC either did not collect or OMC did not provide sample results taken at the outfall; consequently, the highest measured PCB concentration in the sediments was 8400 ppm.

The ENCOTEC data are significant in that the PCB concentration differed by several orders of magnitude depending upon the depth; this was especially true of borings H-1, H-2 and H-3 taken in Slip #3. Later Mason & Hanger's onsite investigation at the ENCOTEC sample points showed that the differences correlated with depth locations of the top soft muck-like sediments, underlying sand layer, and bottom hardpan clay. Mason & Hanger concluded that the underlying sand and clay layers were relatively uncontaminated (less than 5 ppm) with respect to PCB at locations away from the plant outfall, even though the top muck sediments may contain over 50 ppm PCB.

3.2.2.3 Battelle, Pacific Northwest Laboratories

Battelle, Pacific Northwest Laboratories, under contract with the U.S. EPA, evaluated alternatives for removal/destruction of PCB contaminated sediments in Waukegan Harbor. Battelle recommended (1) removal of the contaminated bottom sediments using a hydraulic pipeline dredge (no cutterhead), (2) dewatering of the sediments in a sedimentation lagoon, and (3) burial in the Browning-Ferris landfill near Zion, Illinois.

Battelle, having available only the Illinois EPA core samples, preliminary U.S. EPA analyses, and ENCOTEC results, estimated the quantity of sediments in excess of 10 ppm PCB as 102,000 cubic yards. No distinction was made between the type of sediment (muck, sand, or clay). The assumption was made that the sediment core length collected corresponded to the sediment depth (100 percent recovery) for the purpose of estimating sediment quantities to be removed. The sediment removed was assumed to be mostly sand or partially sand which would settle and dewater in a lagoon within hours using a polymer to settle turbidity.

3.2.2.4 University of Wisconsin Sampling

The University of Wisconsin, under the direction of Dr. David Armstrong, collected the topmost portions of Waukegan Harbor sediments at 18 locations on July 17, 1978, and analyzed them for PCB and percent solids. A ponar-type sampler was used for 16 locations and a Kahlsico Rectangular Box Sampler was used for two locations. Analysis results are in the appendix. The work was performed under subcontract to JRB Associates, Inc., of McLean, Virginia for the U.S. EPA.

3.2.2.5 U. S. Army Corps of Engineers 1980 Examination Soundings

A detailed map showing water depths to the top of the sediment layer in the lower portions of the Harbor (up to but not including Slip #1) was completed by the U. S. Army Corps of Engineers based on May 1980 soundings.

3.2.2.6 Environmental Research Group, Inc. (ERG)

The Environmental Research Group, Inc. (ERG), under subcontract to JRB Associates, Inc. collected and analyzed water samples and sediment core samples taken at various harbor locations. JRB Associates, Inc. is under contract with the U.S. EPA to (1) examine contamination of ground water aquifers and (2) quantify the rate of release of PCBs to Lake Michigan. Heavy metals (arsenic, cadmium, copper, lead and mercury) were also analyzed. No significant concentration of heavy metal was found over and above levels that would be expected in sediments and in water near an urban area.

The sediment core samples were taken during June, July 1979 at 27 locations using EPA sampling equipment. This consisted of brass or steel sampling tubes, each 4 or 5 feet long and sometimes screwed end to end to permit 8 or more feet of sediment core to be collected; the metal tubes contained a 2 inch diameter plastic liner and a nose cone to retain the sediment samples. The tube assembly was dropped in a vertical position from a dock or boat. The sediment collected was cut into 5 cm segments and each segment analyzed for PCB.

Some very high concentrations of PCB were found in sediments under the now-abandoned OMC outfall discharging into Slip #3. Sample point S02 (identified as ERG-2 in the appendix pocket insert location map) shows an increasing concentration with respect to sediment depth. This sediment core was sectioned into 5 cm lengths, each section analyzed for PCB (mg/kg or ppm of PCB on a dry weight basis) and reported as follows:

1800 ppm PCB (top of muck sediment)
24800
79000
70400
55000
97000
165000
475000
537000
570000
140000 ppm PCB (bottom of muck sediment)

This core boring taken at the abandoned outfall suggests that liquid PCBs have been discharged in the past, and that some of the liquid PCBs have sunk into the top muck sediments and have pooled at this location. The total depth of muck from which the core was taken was not reported.

This "pool" of PCB appears to have spread out laterally from the outfall resulting in very localized pockets of high PCB concentration adjacent to areas of much lower concentration. The ERG core borings 3 and 3D taken at the same location approximately 100 feet from the outfall illustrate this (3 foot total depth):

Boring ERG-3 (S03)	Boring ERG-3D (D03)
2500 ppm PCB	5200 ppm PCB Top of Muck
25	3100
20	27000
1000	21000
111	19000
64	8400
100	14000
90	120000
34000	21000
46	330000
72	200000
19000	28000
59000	52000
46000	74000
17000	420000
440000	91000
630	330 Bottom of Muck
370	310 Top of Sand

EPA and ERG personnel collected 7 additional sediment samples on September 3-4, 1980. The analysis results were not available at the writing of this report. A Mason & Hanger employee observed collection procedures and noted (1) that the EPA core sampler easily penetrated the top muck sediments coming to rest on the underlying sand or clay, and (2) the core length was less than the muck thickness at the sample location. Because core sample recovery was less than 100% (sometimes as little as 30%), core sample length information could not be used to estimate the depth of a sample segment or thickness of the muck layer.

Mason & Hanger concluded upon examining the EPA-ERG sample data that the entire top soft muck sediment layer is contaminated with PCBs down to the underlying sand at all or almost all locations where any contamination occurs. The data are in the appendix.

3.2.2.7 Argonne National Laboratory Study

Argonne National Laboratory completed a field study during the period April 22, 1979 through September 23, 1979 measuring the average daily Waukegan Harbor water level. Surface and bottom water currents were also measured in 51 non-consecutive days. Argonne concluded that the average harbor water exchange rate was about 2.8 cubic meters per second which could result in a complete exchange of harbor water every four days. On two occasions, the bottom currents were high enough (0.4 meters/sec) at times to resuspend some bottom sediments. Water levels did not vary more than 2.5 feet during the study period, but variations over one foot occurred within one day.

Argonne also measured water depths to top of sediments throughout the harbor on November 21, 1978.

3.2.2.8 Soil Testing Services, North Brook, Ill.

Soil Testing Services, Inc. of North Brook, Illinois, under contract to OMC or an agent of OMC, completed a series of Waukegan Harbor bottom sediment borings using a Osterberg piston sampler. The method used was such that the heavily-contaminated top soft muck sediment was completely bypassed and only the underlying sand and hardpan clay was sampled. Soil Testing Services, Inc., recognized the existence of separate sand and clay layers and attempted to obtain samples of sand and of clay at selected depths and locations in the harbor. The results are in the Appendix. None of the sand or clay samples showed contamination in excess of 5 ppm PCB (the most contaminated sample was 2.2 ppm PCB). This work was performed in November 1976 by Soil Testing Service.

3.2.2.9 Conclusions Learned From Previous Studies

1. The studies defined areas of PCB contamination in the harbor (Figure 7). Sediments in Slip #3 are contaminated in excess of 500 ppm PCB; contamination in the upper reaches of Slip #3 exceeds 100,000 ppm.

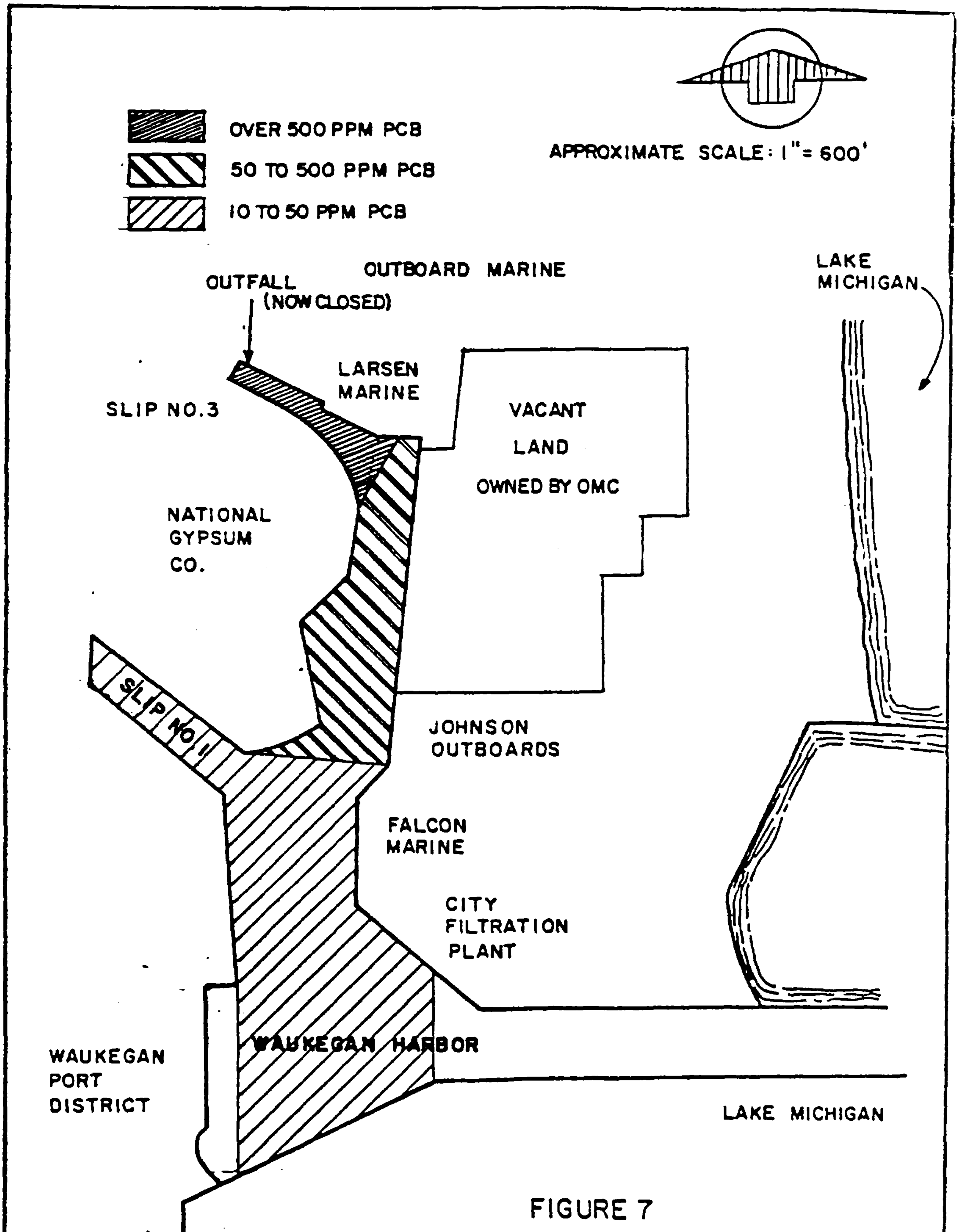


FIGURE 7
EXTENT OF PCB CONTAMINATION
IN WAUKEGAN HARBOR BY CONCENTRATION

2. The PCBs readily adsorb onto the top soft muck sediments. These muck sediments move to some degree into the harbor proper as the result of water currents. In addition, water levels in Slip #3 contain about one part per million soluble PCB (EPA sampling in May 1979).

3. The sand and hard clay underneath the soft muck sediments appear to be uncontaminated at harbor locations away from the OMC outfall.

4. Mason & Hanger agrees with the general approach recommended by Battelle for harbor cleanup, namely; (1) dredging, (2) dewatering of dredge spoils in lagoons, (3) returning treated water back to the harbor, and (4) landfilling the dewatered solids.

3.2.3 Mason & Hanger Studies

3.2.3.1 Determination of Physical Properties of Sediments

While previous studies delineated PCB concentrations in the harbor sediments, little analysis had been performed on the physical nature of the sediments. Information such as particle sieve size, density, percent moisture, sedimentation rate, etc. should be known before (1) dredging method can be specified, (2) sedimentation basin and lagoon can be designed, or (3) whether the dewatered solids should be landfilled, incinerated, or disposed of by some other method.

Warzyn Engineering, Inc., Madison, Wisconsin, under subcontract to Mason & Hanger, (1) collected 5 gallons of sediment from six harbor locations and (2) took sediment core borings at each of the six locations down to clay. This work was performed July 1-2, 1980. Warzyn's report was submitted in August 1980. Raltech Scientific Services, Inc. performed analytical work on the samples collected, each delivered under Chain of Custody. Mason & Hanger measured sieve size and density of the samples collected. The sediment samples were also slurried with Waukegan Harbor water, allowed to settle in the laboratory, polymer added to settle fines, and the water passed through a sand filter and carbon filter simulating a proposed treatment. Results of this study are in the appendix.

The study demonstrated that Waukegan Harbor sediments consist of a (1) top soft "muck" layer, a (2) middle sand layer, especially thick in Slip #3, and (3) an underlying hard clay layer. Warzyn Engineering, Inc. described the muck as "very soft, black organic clayey silt, trace to some sand". The muck contained an average of 50 percent solids and average specific gravity of 1.4. Over 75 percent of the material could be slurried wet through a 200 mesh screen (at most locations).

The muck contained 3 to 4 percent volatile solids. The muck could easily be slurried with water, simulating a hydraulic dredge pumping the sediments to a lagoon.

Clay samples taken at three locations in the upper portions of the harbor were found to be uncontaminated with PCB (Locations W2N-1, W2N-2 and W2N-3 of the pocket insert map in the appendix).

3.2.3.2 Measurement of Top Muck Sediment Thickness

The EPA-ERG data showed that if the uppermost muck layer is contaminated at a particular location, contamination occurred throughout the muck layer. The muck layer offers very little resistance to heavy weights, and its depth could be easily measured using a pipe or metal probe. Sediment core samplers could easily penetrate this muck layer, but 10 to 20 blows were required for a core sampler to penetrate even 4 to 6 inches into the underlying sand. The bottom hard clay offered greater resistance sometimes requiring over 30 blows to penetrate 6 inches.

ENCOTEC samples taken near or in Slip #3 at (1) location H-1 (very west end of Slip #3 about 60 feet from OMC outfall), (2) location H-2 in Slip #3 about 250 feet east from the OMC outfall, and (3) location H-3 about 600 feet east from the OMC outfall showed very little contamination (less than 5 ppm PCB) in the underlying sand even though the top muck sediments contained over 100 ppm (as high as 8,000 ppm) PCB.

A Mason & Hanger employee accompanied ERG and EPA during collection of sediment (muck) samples on September 3-4, 1980. Different weights (a lead weight used by EPA to measure depths, a secchi disk, and another weight borrowed from Falcon Marine) were dropped to compare water depth. Despite different pressures on the muck, the different weights all gave the same depth reading. This indicated that depth measurements reported by the various studies were reliable, as the weights did not penetrate the muck. A 0.75 inch diameter pipe probe easily penetrated the top muck layer down to sand or clay and was demonstrated to be an effective tool in measuring the thickness of that layer. Muck layer thicknesses, measured at 22 harbor points, varied from zero to 10.4 feet.

Mason & Hanger employees using a secchi disc and pipe probe mapped out the muck layer thickness throughout the upper part of the harbor including both slips during the period of November 17-20, 1980. From this information, maps showing water depths, depths to sand, and muck layer thicknesses were drawn. Measurements taken of thicknesses at the same locations as Warzyn (July 2, 1980) and ENCOTEC (April 1977) were approximately in agreement.

The muck sediment layer thickness was found to vary considerably with respect to location (Figure 8 and appendix). Because of this variation, and the understanding that the entire muck layer at any given location is contaminated, estimates of total sediment volume to be removed are difficult. Consequently, earlier studies have estimated anywhere from about 50,000 cubic yards to about 250,000 cubic yards of contaminated sediments greater than 10 ppm based on only a

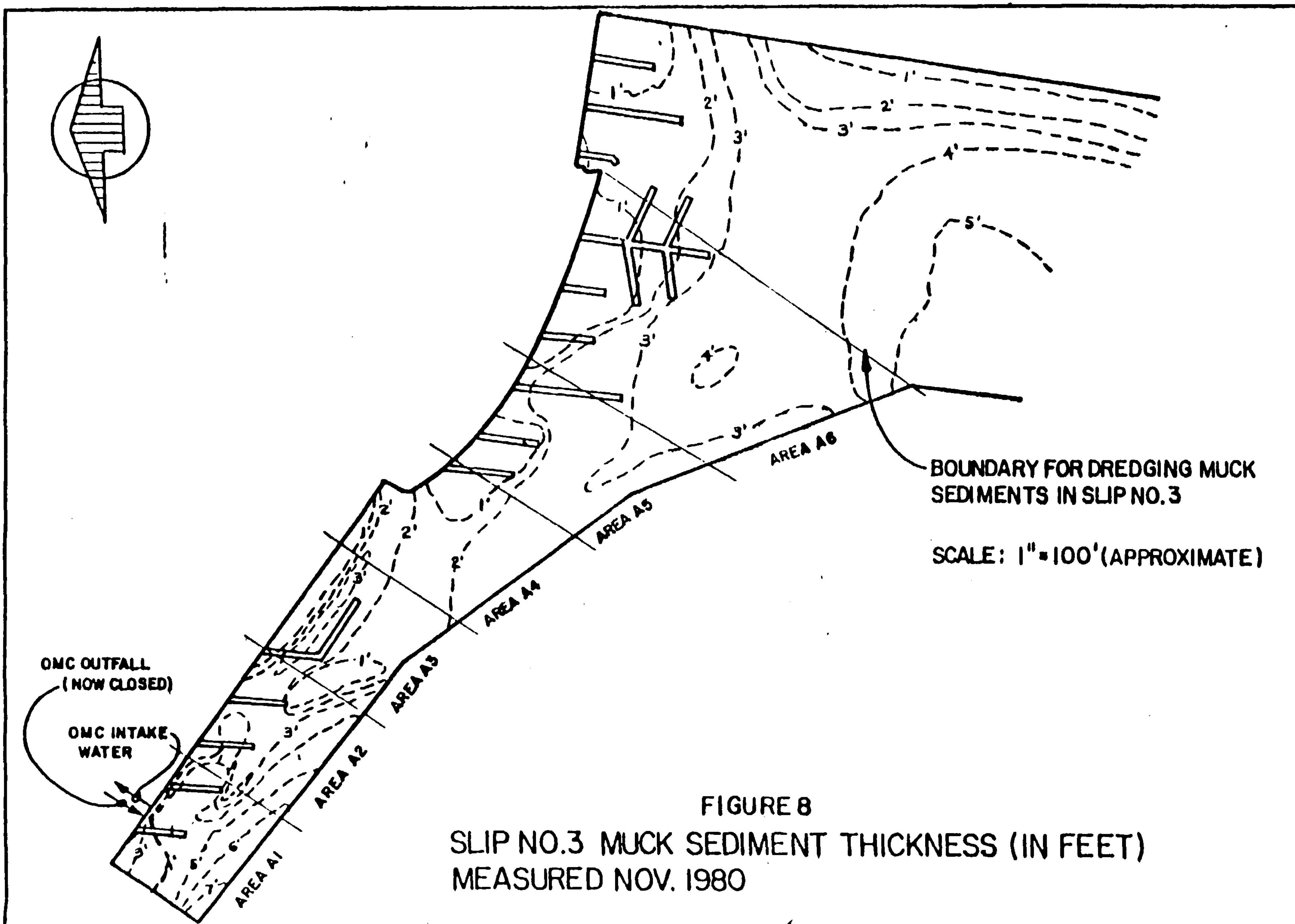


FIGURE 8
SLIP NO.3 MUCK SEDIMENT THICKNESS (IN FEET)
MEASURED NOV. 1980

small quantity of sediment core measurments. A one foot error in estimation of average muck depth thickness when estimating sediments greater than 10 ppm PCB can result in an error of 45,000 cubic yards of sediment.

3.2.3.3. Measurements of Depth of PCB Penetration Into Sediments at OMC Outfall

The analytical results (described in Section 2.2.2.8) showing depths of PCB penetration into soils at the OMC outfall in the North Ditch area first became available in late September 1980. The results showed large quantities of PCB (in excess of 100,000 ppm concentration) pooled beneath the North Ditch outfall, sinking through the bottom sand all the way to the underlying silty clay, to a depth of almost 25 feet to the top of the silty clay. Mason & Hanger concluded that if the PCBs penetrated through sand at the North Ditch outfall, then penetration through sand may also have occurred at the Waukegan Harbor Slip #3 outfall. The ERG data showed that a pool of PCB existed above the sand at the Slip #3 outfall, and it seemed reasonable to expect that the PCBs would sink into Slip #3 sand.

The Soil Testing Service Boring Number 15 near the plant outfall in Slip #3 showed one sample into sand of only 0.1 ppm PCB. However, their report did not indicate exactly where the point was located. The North Ditch study showed zones of no PCB contamination near zones of over 10,000 ppm PCB contamination. Mason & Hanger could not conclude that the sand was uncontaminated on the basis of one point.

Therefore, Mason & Hanger subcontracted in November 1980 with Warzyn Engineering, Inc. to collect underlying sand and clay samples at six locations in Slip #3. The first contract performed July 2-3, 1980 called for one core boring in the upper reaches of Slip #3 near the plant outfall for PCB analysis. A suitable barge which could maneuver into Slip #3 was not available at the time so a core sample towards the outlet of Slip #3 was substituted.

Figure 9 illustrates the locations of Warzyn Engineering, Inc. core borings in Slip #3 in relation to the ENCOTEC core borings and OMC outfall. Figure 10 shows a depth profile. Warzyn reported that the top muck layer offered essentially no resistance to core boring equipment, but a blow count of 5 to 15 was required to penetrate each 6 inches into the sand and blow count of 15 to 32 was required to penetrate each 6 inches into clay.

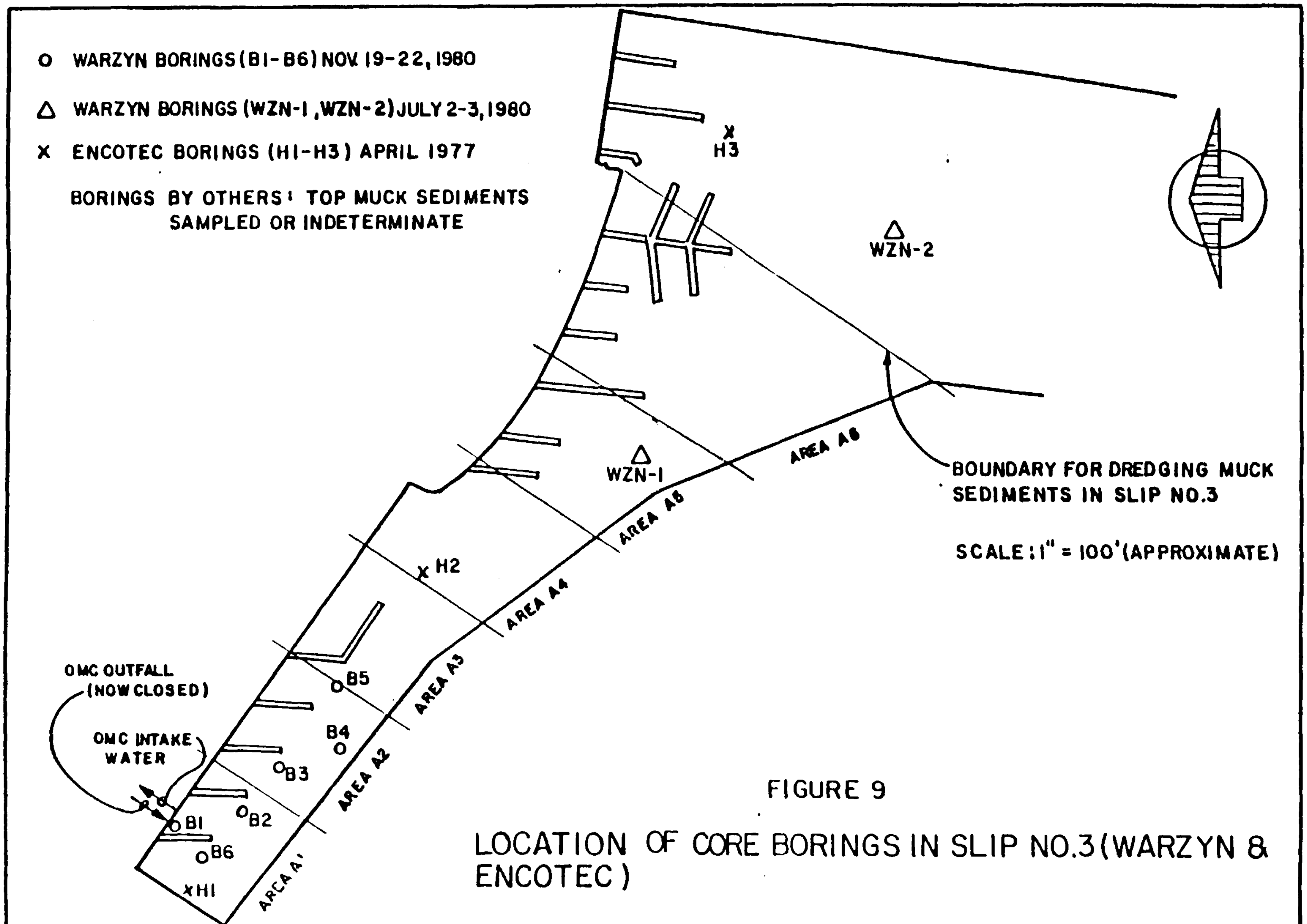


FIGURE 9

LOCATION OF CORE BORINGS IN SLIP NO.3 (WARZYN & ENCOTEC)

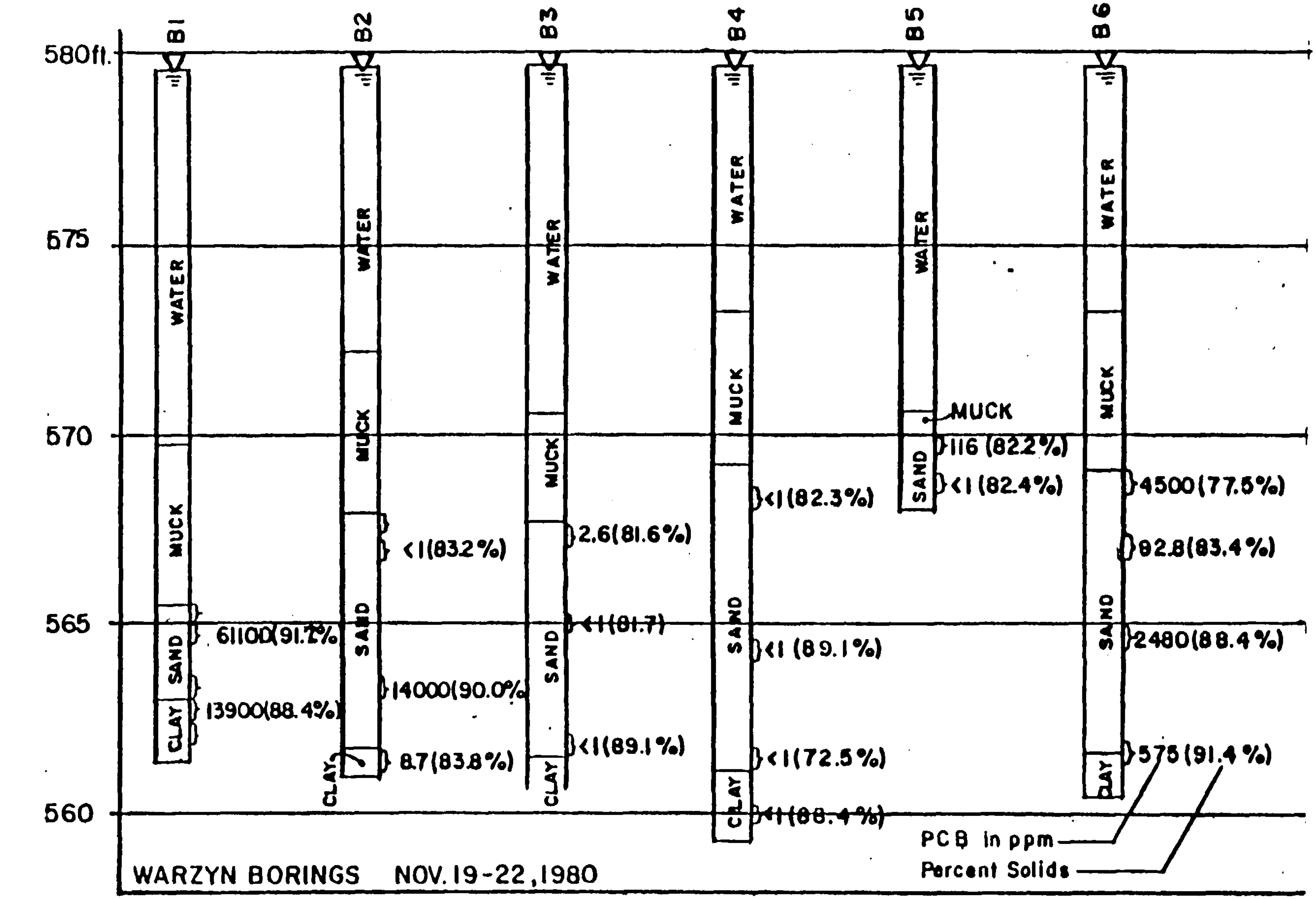


FIGURE 10

PCB ANALYSIS OF SLIP NO. 3 CORE BORINGS B1 – B6

Sediments depth of the various samples are listed below (the Warzyn depths are uncorrected for variation in water level; ENCOTEC results are corrected to 579.8 USGS Datum):

Sample	Date	Depth to Muck	Depth to Sand	Depth to Clay
B1 (Warzyn)	Nov 22 1980	9.8 feet	14.2 feet	16.7 feet
B2 "	Nov 21 1980	7.5 "	11.7 "	18.0 "
B3 "	Nov 21 1980	9.2 "	12.0 "	18.1 "
B4 "	Nov 20 1980	6.0 "	10.0 "	18.5 "
B5 "	Nov 19 1980	9.2 "	9.7 "	*
B6 "	Nov 21-22 1980	6.5 "	10.6 "	18.0 "
W1 "	July 2 1980	15.0 "	18.0 "	21.5
"				
W2 "	July 2 1980	18.0 "	22.5 "	24.5 "
H1 (Encotec)	April 1977	11.3 "	15.3 "	19.8 "
H2 "	April 1977	11.3 "	13.3 "	19.8 "
H3 "	April 1977	16.5 "	18.5 "	20.8 "

*sounded 2 feet into sand; debris present?

The sand depth in Slip #3 varied from 2 feet to 8 feet for the samples collected. In addition to PCB analyses, Mason & Hanger requested percent moisture, density, and particle size analysis for different depths at each of the six sample points (B1 thru B6). These results are presented in the appendix. Raltech Scientific Services of Madison, Wisconsin, was contracted to perform the PCB analysis.

As of December 31, 1980, Raltech Scientific Services completed 18 of the 42 core samples sent to them for PCB analysis. The results, displayed in Figure 10, show that PCBs have penetrated the sand and even into the top portion of the underlying silty-clay layer at boring locations B1, B2 and B6. At locations B3, B4, and B5, which are further away from the outfall, the sand is uncontaminated (except for the top few inches adjacent to the contaminated muck).

Sample point B1 at the outfall shows heavy contamination throughout the sand layer (up to 61,000 ppm PCB) and into the underlying clay. Sample point B2 about 50 feet from the outfall shows areas of no contamination near the top of the sand but heavy contamination deeper just above the clay. Mason & Hanger believes that some of the liquid PCB at the outfall sank into the sand and was intercepted by the clay, and has spread out laterally near the sand-clay boundary. Warzyn reports that the clay at these locations contain considerable gravel which appears to provide channels for further penetration.

3.2.4 Conclusions Learned From Data Collected

1. Waukegan Harbor sediments consist basically of (1) a top soft "muck" layer, (2) an underlying sand layer, and (3) an relatively impervious hard clay-silt layer.

2. Study of available data show that the muck layer is contaminated at all depths at any given location. Contamination is not uniform with respect to depth, and there are hot spots or zones of low contamination at any depth. Contamination is highest near the OMC outfall (over 100,000 ppm) and decreases towards the harbor mouth (about 5 or 10 ppm range).

3. The muck layer varies from zero to 10.5 feet in the harbor and offers essentially no resistance to sediment core boring equipment. The average density is 1.44 grams per cubic centimeter (with variations from 1.29 to 1.69 grams per cubic centimeter). At some locations as much as 85 percent will pass through a 200 mesh screen. The muck may contain some sand, gravel, and/or debris, especially in the upper reaches of Slip #3. Percent solids in situ is typically 50 percent, but higher values (up to 80 percent) occur in the upper reaches of Slip #3. When slurried with water, several days may be required before the solids will settle and dewater to the same degree as they occur within the harbor. Curly Leaf Pond Weed grows profusely in the far end of Slip #3 near the OMC outfall.

4. The sand layer in Slip #3 varies from 2 to at least 8 feet, depending upon location. In the harbor proper, the sand may be less defined and at some locations is very thin or absent altogether or is mixed with muck or clay. With the exception of locations near the OMC outfall, the sand is essentially (less than 5 ppm) uncontaminated with respect to PCB. The sand under the muck is contaminated with PCB up to a radius of about 75 feet from the outfall.

5. The underlying gray hard clay-silt is generally impervious (about 10^{-7} cm/sec permeability coefficient), but may contain some gravel, sand, and thin organic seams. Measurable PCB concentrations (over 1 ppm) have not been found in this underlying layer except for the clay-silt at the old outfall.

6. Examination of available data taken by various groups failed to show <u>major</u> changes in harbor sediment concentrations during the several year time frame; not enough sampling has been done to determine whether moderate changes occur.

3.2.5 Estimation of PCB Contamination

3.2.5.1 Contamination in Top Muck Sediment Layer

Figure 7 illustrates locations of contaminated sediments (1) greater than 500 ppm PCB, (2) between 50 and 500 ppm PCB, and (3) between 10 and 50 ppm of PCB. Areas not shaded may have measureable PCBs but average less than 10 ppm. Hydroscience, Inc., (now called Hydroqual, Inc.) in a study funded by U.S. EPA, has concluded on a preliminary basis that dredging or removal of harbor sediments at concentrations less than 10 ppm PCB would not measurably further decrease PCB concentrations in fish that reside in the harbor. The unshaded areas D1, D2, and D3 are marginal at 10 ppm PCB based upon very limited sampling.

Mason & Hanger did not attempt to correlate contamination levels with sediment depths because percent sediment recovery differed with the various core borings collected. A PCB concentration taken at say a foot deep core boring did not necessarily mean that the sample came from a depth of one foot. However, where core borings were taken and showed contamination, the entire muck layer generally appeared to be contaminated. The muck layer thickness could be easily measured (Section 3.2.3.2); therefore it made sense to estimate the cubic yardage of contaminated sediments in terms of cubic yardage of muck sediments.

In November 1980, Mason & Hanger measured sediment depths throughout the Harbor (section 3.2.3.2). The harbor was then arbitrarily divided into sections (as illustrated by Figure 11). An average PCB concentration was calculated by first averaging the concentration determined for each sample location and then taking an average of all locations within each section. The same was done for percent moisture. An average muck depth (thickness) was calculated by subdividing each section into 16 to 30 equal sized grid squares, and then reading off the depth from the muck depth contours. The results of these calculations are listed in Table 2.

The revised estimates of in situ muck contaminated sediments, excluding sand contamination in Slip #3, are as follows:

Contamination over 500 ppm PCB (Area A):	7,300 cubic yards
Contamination over 50 ppm PCB (Areas A & B):	45,000 cubic yards
Contamination over 10 ppm PCB (Areas A, B & C):	166,000 cubic yards

Table 2 shows that area A6 has an average concentration of 380 ppm PCB. It is included in the category of "over 500 ppm PCB" because there are sufficient localized concentrations above 500 ppm to warrant its inclusion. The same reasoning holds for including area B5 in the category of over 50 ppm PCB. On the other hand, there are a few spots marginally above 10 ppm outside areas A, B, and C that were not included because they were judged not to have a very great impact.

The total pounds of PCB still existing in Waukegan Harbor is difficult to estimate because of the skewed distribution of PCBs, especially in Slip #3. Using the data available, the total amount of PCBs is calculated as follows:

$$\text{Pounds of PCB} = C\ S\ Y\ D\ (27)\ (10)^{-8}$$

Where C = average concentration of PCB in ppm (dry weight basis)
S = average percent solids (varied from 22 to 82 percent depending upon location)
Y = cubic yardage of muck sediment
D = density of muck sediemnts (an average value of 89.7 lbs per cubic foot was used).

LOCATION	ESTIMATED CUBIC YARDS SEDIMENT	CALCULATED LBS. OF PCB
A1 TO A6	7,300(MUCK) PLUS 1600(SAND)	250,000
B1 TO B5	38,000 (MUCK)	7,000
C1 TO C6	121,000 (MUCK)	2,200
D1 TO D3	18,000 (MUCK)	300

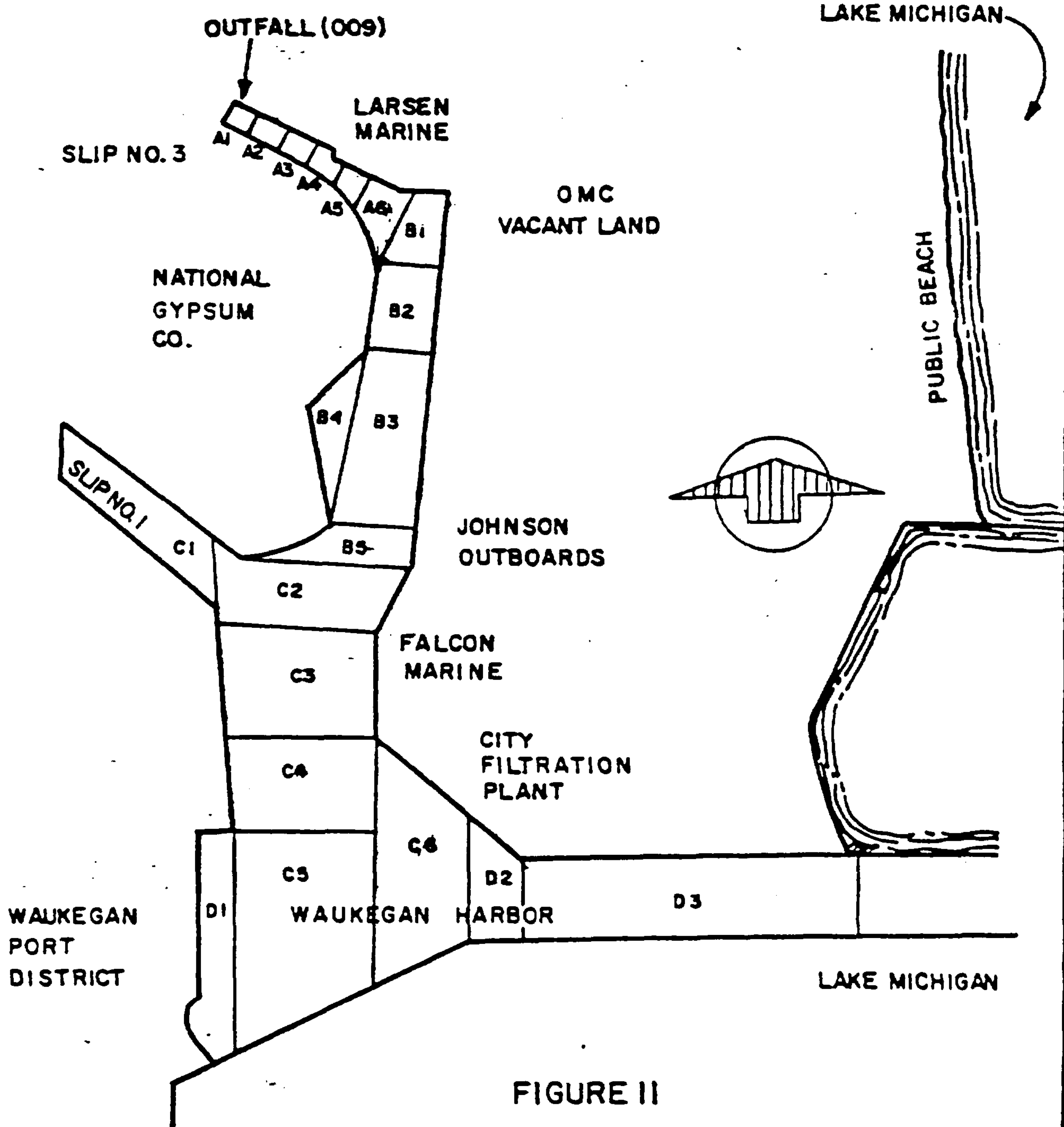


FIGURE II

EXTENT OF PCB CONTAMINATION IN SEDIMENT IN WAUKEGAN HARBOR BY AMOUNT

TABLE 2

Extent of PCB contamination in Sediments in Waukegan Harbor (in situ)

Location	Avg. PPM PCB	Avg. % Solids	Avg. Ft. Depth	Amt of Contaminated Sediment C.Y. Muck	Lbs. of PCB
A1	54,960	69.6	4.73	1,261	116,822*
A2	54,796	75.8	2.96	789	79,359*
A3	11,020	81.9	1.82	508	11,104*
A4	2,028	80.0	1.80	553	2,173
A5	773	50.5	2.21	1,125	1,064
A6	341	53.5	2.61	2.939	1,299
Total A1 - A6				7,275 C.Y.	211,831 Lbs.
B1	256.3	48.9	2.98	5,510	1,672
B2	143	79.7	4.95	11,550	3,188
B3	99.7	42.7	4.28	14,825	1,529
B4	103.2	49.6	3.25	3,792	470
B5	47.1	56.5	1.16	1,897	122
Total B1 - B5				37,574 C.Y.	6,981 Lbs.
C1	16.4	35.8	3.23	11,855	169
C2	15.7	61.1	2.63	15,219	354
C3	12.2	60.8	4.61	25,253	454
C4	33.0	21.5	5.7 est.	23,351 est.	402
C5	19.4	40.0	3.7 est.	34,958 est.	589
C6	14.13	59.2	2.65 est.	9,815 est.	199
Total C1 - C6				120,451 C.Y.	2,167 Lbs.
D1	9.7	75.2	0.5 est.	2,200 est.	39
D2 } D3 }	7.5	73.8	2 est.	7,637 est.	102
			1 est.	8,533 est.	144
Total D1 - D3				18,370 C.Y.	255 Lbs.
Overall Totals For Muck				183,670 C.Y.	221,234* Lbs.

Sand Contamination in area A1:
- Volume of Contaminated Material: 800 to 2000 C.Y.
- Pounds of PCBs: Estimated 20,000 to 50,000 Lbs.

*The pounds of PCBs may vary by an order of magnitude depending upon how core borings are grouped and averaged. See Section 3.2.5.1.

Table 2 presents one estimate of total amount of PCB, obtained by taking an arithmetic average of all the segments of a particular boring into the muck sediment, and then taking an arithmetic average of the different borings. Needless to say, a more realistic average would be obtained if there were a greater number of samples to present a better sample basis. Unfortunately this is not the case in locations A1, A2 and A3 in Slip #3.

Table 2 presents an estimate of 221,000 pounds of PCB in the muck sediments in Waukegan Harbor. A large percentage of these PCBs are confined to areas A1, A2 and A3 of Slip #3. Two or three core borings near the outfall with very high concentrations of PCBs strongly influence the calculations for total PCB in Waukegan Harbor. If the two core borings ERG-2 (S02) and ERG-D3 (D03) were ignored, the total PCBs in Waukegan Harbor would be calculated to be about 117,000 pounds rather than 221,000 pounds.

Dr. Robert V. Thomann, of Hydroqual, Inc., formerly Hydroscience, Inc.) consultant to EPA Region V, has suggested using geometric means rather than arithmetic averages of PCBs as a method of tempering the skewedness of the data. The geometric mean would give less weight to the larger PCB concentrations. Mason & Hanger using geometric means rather than arithmetic averages from areas A1, A2 and A3, calculates, 90,000 pounds of PCB rather than 207,000 pounds of PCB for that part of Waukegan Harbor. Estimates on the quantity of PCB in Waukegan Harbor therefore depend upon how the core boring points are grouped together to compute averages and whether geometric means or arithmetic averages are used. Mason & Hanger favors arithmetic averages of PCB concentration weighted according to the volume of muck for calculating the total amount of PCBs. More muck core borings are needed in regions A1, A2 and A3 in order to better estimate the total amount of PCBs present.

For the purpose of engineering a plan for removal of PCB-contaminated sediments from Waukegan Harbor, it is sufficient to know that some Slip #3 sediments are very heavily contaminated. The actual number of pounds of PCB, whether 50,000 or 250,000 pounds, has little bearing on the proposed removal method.

3.2.5.2 Contamination in the Underlying Sand and Clay Layers.

As of December 31, 1980, Raltech Scientific Services completed 18 of the 42 chain of custody samples assigned to them for analysis. The sand and clay contamination appears to be confined to Area A1. ENCOTEC sample point H1 did not show evidence of contamination. This indicates that not all sand or clay within area A1 is contaminated. On the other hand, it is not known whether "fingers of PCB contamination" have migrated into area A2 bypassing boring locations B3 and B4, or into the sand and clay under the sheet pilings north of the slip. Mason & Hanger recommends more core samples be taken including the area north of Slip #3 near the old outfall to define the contamination before detailed plans for removal are finalized.

Mason & Hanger estimates the amount of sand within area A1 to be 1500 cubic yards (72 feet by 100 feet area, sand layer 5.6 feet deep on the average). If the clay is contaminated to an average depth of 18 inches, this adds another 400 cubic yards of material. Not all the sand or clay within area A1 is contaminated, and there could be some contamination outside area A1. The amount of contaminated material appears to be between 800 and 2,000 cubic yards exclusive of possible shore contamination.

For the purpose of obtaining an order of magnitude estimate on the amount of PCBs present, Mason & Hanger assumed that contamination was confined to a 80 foot diameter circle whose center is the geometric center of locations B1, B2 and B6. The number of cubic yards of contaminated material within this circle exclusive of shore material was estimated to be 1150. The arithmetic average PCB concentration of core borings B1, B2 and B6 was 10,700 ppm. The average solids was 86.9%. Assuming a density of 110 pounds per cubic foot for sand, PCBs were calculated to be 41,400 pounds. If a 60 foot rather than an 80 foot diameter circle is used, then the amount of PCB is 26,000 pounds.

3.3 Summary of Estimates of PCBs in Situ

Location	Concentration	Pounds of PCB	Cubic Yardage
Slip #3 (Area A)	Over 500 ppm PCB	1. From 50,000 to 225,000 lbs. 2. 20,000 to 50,000 lbs. in sand and clay	1. 7,300 cy of muck 2. 800 to 2,000 cy of sand and clay
Upper part of Harbor (Area B)	50 to 500 ppm PCB	1. 7,000 lbs in muck 2. none in sand over 10 ppm	1. 38,000 cy muck 2. No sand
Lower Part of Harbor (Area C)	10 to 50 ppm PCB	1. 2,200 lbs in muck 2. None in sand over 10 ppm	1. 121,000 cy muck 2. No sand

Total Cubic Yardage: 168,000 cy of sediments over 10 ppm PCB including possibly 2,000 cy of sand and clay in Slip #3

Total pounds of PCB: 70,000 to 275,000 lbs of PCB in harbor total. About 96 percent of the total PCB contamination is in Slip #3

4.0 DISCUSSION OF APPLICABLE GOVERNMENTAL REGULATIONS

4.1 Introduction

This section will discuss the laws applicable to remedial programs involving PCB contaminated wastes and the governmental agencies having jurisdiction.

4.2 Applicable Laws and Regulations

Following is a listing of applicable laws and regulations governing remedial programs involving PCB contaminated wastes. A brief discussion of each law is included to indicate its relevance to any proposed remedial program. In addition, the governmental agency responsible for administering the law or regulation is listed.

The laws and regulations to be discussed are:

a. Clean Water Act

b. River and Harbors Act

c. Resource Conservation and Recovery Act

d. Toxic Substance Control Act

e. Illinois Environmental Protection Act

f. Illinois Pollution Control Board Rules and Regulations

g. Illinois Rivers, Lakes and Streams Act

h. National Environmental Policy Act

i. Hazardous Material Transportation Act

j. City of Waukegan Construction and Electrical Permits

4.2.1 Clean Water Act of 1977 (PL 95-217)

Section 404 authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits, after notice and opportunity for public hearings, for the discharge of dredge or fill material into the waters of the United States at specified disposal sites. The selection and use of disposal sites will be in accordance with guidelines developed by the Administrator of the EPA in conjunction with the Secretary of the Army, published in 40 CFR Part 230. If these guidelines prohibit the selection or use of a disposal site, the Chief of Engineers may consider the economic impact on navigation of such a prohibition in reaching his decision. Furthermore, the Administrator can prohibit or restrict the use of any defined area as a disposal site whenever he determines, after notice and opportunity of public hearings and after consultation with the Secretary of the Army, that the discharge of such materials into such areas will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wild life, or recreational areas. The regulations are discussed in detail in Army Corps of Engineers Permits Program Regulations (33 CFR 320 through 329).

Thus, such a permit might be required for the temporary or permanent disposal of dredge material from Waukegan Harbor. Interpretation of these regulations would indicate that Waukegan Harbor is a navigable waterway subject to these portions of the law. The North Ditch is also a navigable waterway, and it also appears that the remedial action envisioned for it may be subject to permitting under this provision. However, if no water or sediment is returned from this action to navigable waters of the United States, then a Section 404 permit would likely not be required for the North Ditch.

Section 402 may require a National Pollutant Dicharge Elimination System (NPDES) permit from the Illinois Environmental Protection Agency for the point source discharge of treated water from storage or dewatering of the PCB contaminated sediments or soils. This is due to the dewatering process probably involving treatment beyond Section 404 ambit. There are presently no federal effluent limitations for PCBs for this type of operation. In addition, Section 401 may require certification from the State of Illinois that the discharge of treated water will meet with applicable state effluent limitations and water quality standards. This would probably have to be received prior to the Corps of Engineers permit issued under Section 404. A certification obtained for the construction of any facility must also pertain to subsequent operation of the facility.

Section 311 of the Clean Water Act gives the Federal Government the authority and sets up a mechanism to respond to a pollution emergency. A pollution emergency occurs in the event of an emergency oil or hazardous waste spill or where there is an imminent and substantial threat of public health and welfare because of an actual or threatened discharge of oil or hazardous substance into or upon the waters of the United States. Section 311 and the implementing regulations establishes a "contingency plan" that identifies who is responsible for all situations where an oil or hazardous material spill occurs. The contingency plan identifies a "National Response Team" (NRT), "Regional Response Team" (RRT), and an "On-Scene Coordinator" (OSC) as the parties most involved in ensuring the proper cleanup of harmful environmental situations. While USEPA and the U.S. Coast Guard have the main responsibility for implementing the regulations, almost all other agencies can offer advice to the RRT in their area of expertise.

Once an oil spill or hazardous waste site is identified as threatening or has actually entered waters of the United States, this spill can be classified as 311 actionable. Generally an OSC is assigned to a large spill or cleanup activity. The discharger is then given an opportunity to clean up the area on its own, while the OSC monitors the activities. If the spilling party refuses to take action, or for other reasons is not performing effectively, the OSC can initiate Federal activity to ensure public safety and the protection of United States waters. The OSC shall direct Federal efforts at the scene of a discharge or potential discharge. The OSC will also consult regularly with the RRT in carrying out a cleanup activity. The RRT serves as an advisory team to the OSC.

Once a discharger refuses to clean up the spill himself, the OSC, and RRT, with the approval of the Coast Guard can initiate containment and clean up activities using funds for that purpose authorized under Section 311(k) of the Clean Water Act.

4.2.2 River and Harbors Act of 1899

Section 10 of this act may require a permit to be obtained from the Corps of Engineers so that dredging may proceed. The law says it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of, any harbor, etc., of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army prior to beginning the same.

Any dams or dikes across a navigable waterway are governed under Section 9 and pertain to the requirement for Congressional consent and approval (a permit) of the construction plans by the Chief of Engineers and the Secretary of the Army. Containment or dewatering dikes may require these permits.

Only one permit application should be required for all of the work covered under Section 10 of this Act and Section 404 of the Clean Water Act. In addition, this permit application could probably incorporate all aspects of the work in the North Ditch and Waukegan Harbor, as well as any beach area.

4.2.3 Toxic Substances Control Act (TSCA)

The disposal of PCBs is regulated under this act. The Resource Conservation and Recovery Act will probably merge the TSCA regulations into its final rules to avoid potential overlap. The various possibilities for disposal are described at 40 CFR 761 published in Federal Register May 31, 1979. Annex I, Section 761.4, details incineration requirements; Annex II, Section 761.41, covers chemical waste landfills; Annex III, Section 761.42, storage for disposal; Annex IV, Section 761.43, decontamination; Annex V, Section 761.44, marking formats; Annex VI, Section 761.45, records and monitoring.

Section 6(e) of TSCA requires EPA to control the manufacture, processing, distribution in commerce, use, disposal, and marking of polychlorinated biphenyls (PCBs). On February 17, 1978 EPA published the PCB Disposal and Marking Rule in the Federal Register (43 FR 7150). Clarifying amendments to this rule were published on August 2, 1978 (43 FR 33918) and were then superseded by the final rules published May 31, 1979.

Section 6(e)(2) provides that no person may manufacture, process, distribute in commerce, or use any PCB in a manner other than a "totally enclosed manner" after January 1, 1978, except to the extent EPA authorizes activities in a non-totally enclosed manner.

Section 6(e)(3) provides that no person may manufacture any PCB after January 1, 1979, or process or distribute in commerce any PCB after July 1, 1979, except to the extent that EPA specifically exempts such activities.

PCB substance is defined in the regulations as a biphenyl molecule that has been chlorinated to varying degrees. "PCB-Item" is a PCB-contaminated article, container, equipment, including dredging spoils, where the concentration of PCB is 50 ppm or greater. (FR May 31, 1979). A recent decision by the District of Columbia Court of Appeals might change this concentration figure.

Any PCB substance or PCB item (including contaminated soils, dredging solids, contaminated containers) in concentrations of 50 ppm but less than 500 ppm can be disposed in a Chemical Waste Landfill licensed to receive PCBs. The ruling applies even if the substance is liquid. Criteria for Chemical Waste Landfills are published in FR May 31, 1979 page 31522 (paragraph 761.41).

Liquids containing 500 ppm or more of PCBs must be disposed by incineration. Solid PCB or PCB items (non-flowing) in any concentration of PCBs may still be disposed in a Chemical Waste Landfill. Criteria for incineration are published in FR May 31, 1979, page 31551 (paragraph 761.410). Of course, PCB items with any concentration of PCB can also be incinerated.

The EPA rules do not regulate substances containing PCBs less than 50 ppm except that (1) waste oils containing any detectable concentration of PCB must not be used for roads, or for dust control, or as a sealant; and (2) mixing with non-contaminated and low-contaminated materials to achieve less than 50 ppm is not allowed (if the materials should be mixed, the entire mixture would have to be disposed as if it were at the higher PCB concentration before mixing).

PCB non-liquid items of 50 ppm or greater must be disposed of by incineration or in a PCB-approved Chemical Waste Landfill. However, the 50 ppm level as a minimum criteria for materials requiring disposal in accordance with the TSCA regulations has been challenged in court successfully. The result of this decision might be a lowering below 50 ppm as a minimum level to which the waste must be disposed in an approved Chemical Waste Landfill.

Dredge materials and soils which contain between 50 ppm and 500 ppm PCB may also be disposed by alternative methods (other than in a Chemical Waste Landfill or by incineration) if approved by the EPA Regional Administrator. The 50 ppm designated here would again be questionable due to the court's decision.

After January 1, 1983, PCB items including contaminated soils cannot be stored for more than 30 days awaiting disposal unless an adequate roof, walls and a floor with a 6-inch curb is constructed; even then storage for only one year is allowed before disposal.

4.2.4 Resource Conservation and Recovery Act (PL 94-580)

This act provides guidelines for the management of hazardous wastes. In particular, it addresses standards applicable to transporters and generators of hazardous wastes, and also sets standards applicable to owners and operators of hazardous waste treatment, storage and disposal sites. It authorizes state programs and sets up a permitting program for determining compliance with the standards.

The dredged soils and sediments from the OMC site, since they contain PCBs, may be designated as hazardous by the Regional Administrator. Subpart B of 40 CFR Part 261 gives criteria for identifying the characteristics of hazardous waste and for listing hazardous waste. Among these criteria is a standard toxicity test, after which the waste may be labeled as hazardous. The regulations do not specifically address the disposal of dredged wastes, but it may be regarded as hazardous because it contains PCB, which is listed in Appendix VIII as a hazardous constituent. If the Administrator identifies these wastes as hazardous they may then be subject to the requirements of this act. If the contaminated soils and sediments are required to be regulated under RCRA, then the following parts of the regulations will require compliance.

The standards applicable to generators of hazardous wastes are contained in 40 CFR Part 262. Included are the shipping manifests, identification codes, container requirements, and labeling practices now required for hazardous wastes.

The standards applicable to transporters are contained in 40 CFR Part 263 of the regulations. These standards are in agreement with DOT's regulations on the transportation of hazardous waste under the Hazardous Materials Transportation Act.

40 CFR Part 264 contains the standards applicable to owners and operators of hazardous waste treatment, storage and disposal facilities.

EPA's present plans are to merge Toxic Substances Control Act (TSCA) PCB regulations into the final RCRA rules to avoid potential overlap. Therefore, the cleanup must proceed under established TSCA regulations until the ultimate advent of RCRA regulations specifically related to PCBs.

4.2.5 Illinois Environmental Protection Act and Illinois Pollution Control Board Rules and Regulations

Under the Illinois Environmental Protection Act no person shall conduct any refuse-disposal operations without a permit granted by the Agency. Several conditions, including periodic reports and full access to adequate records and the inspection of facilities may be necessary to assure compliance with this Act and with regulations adopted thereunder, after the Board has adopted standards for the location, design, operation, and maintenance of such facilities. For the purposes of this Section "hazardous refuse" shall mean refuse with inherent properties which make such refuse difficult or dangerous to manage by normal means, including, but not limited to, chemicals, explosives, pathological wastes, and wastes likely to cause fire. In addition, disposing of any refuse except at a site or facility which meets the requirements of this Act and of regulations thereunder, will not be allowed.

The Act also prescribes to the Illinois Pollution Control Board the authority to set regulations for the subjects covered under the Act, and to adjudicate permits issued by the Illinois Environmental Protection Agency (IEPA) which are challenged.

The IEPA has the authority to set limitations for the discharge from a dewatering facility through the NPDES program. There are presently no federal effluent standards for the discharge of PCBs from this type of operation. The discharge from the treatment facility might have effluent limitations based on the various chemical parameters as discussed in the IPCB Rules and Regulations, Chapter 3, Water Quality Limits. The IPCB oversees IEPA's Section 401 authority and will submit comments on any request for certification. If application for a permit under Section 404 of the Clean Water Act is made, it should be submitted simultaneously to both the Corps of Engineers and the Illinois Environmental Protection Agency. Only the IPCB is empowered to grant a request to overrule any decisions made by the IEPA impacting Corps of Engineers permit approval.

A Construction Permit is required by IEPA pursuant to the authority contained in Section 13 of the Illinois Environmental Protection Act, Ill. Rev. Stat. 111-1/2. "Construction" hereunder refers to the commencement of on-site fabrication, erection, or installation of a treatment works, sewer, or wastewater sources.

Regardless of whether IEPA requires a NPDES permit, EPA must obtain a construction permit from the state detailing each aspect of construction necessary for the cleanup. The construction permit is the counterpart to an operations permit, which would be satisfied through the NPDES process.

In order for the PCB contaminated soils and sediments (as defined under TSCA) to be disposed of at a non-PCB approved site, a supplemental permit must be obtained by the site operators. Permit applications must be directed to IEPA under authority of Illinois Environmental Protection Act, Ill. Rev. Stat., Ch., 111-1/2, Section 1004. The site must be in compliance with applicable federal regulations governing PCB disposal.

IEPA (Division of Land and Noise) is empowered to issue Special Waste Hauler's Permits for the transportation of PCB contaminated waste (as defined under TSCA) within Illinois. The statutory authority is derived from the Illinois Environmental Protection Act, Ill. Rev. Stat. Ch. 111-1/2 Sections 1005, 1010, 1013, 1020 and 1022.

If the contaminated wastes are moved by a carrier who is licensed as a regulated hauler with either the Interstate Commerce Commission or the Illinois Commerce Commission, then no special waste hauler's permit need be obtained by the hauler for the transportation of PCBs. If, however, the carrier is not regulated, a waste hauler's permit must be obtained from IEPA.

4.2.6 Illinois Rivers, Lakes and Streams Act

The Division of Water Resources (of IDOT) requires a permit for hauling hazardous materials (not wastes) under authority of the Rivers, Lakes and Streams Act, Ill. Rev. Stat., Ch. 19 Section 52-78. The purpose of the Act is to regulate construction to protect the public health, safety and welfare by preventing damage from flooding, shore erosion, etc.; to prevent unmitigated damage to the natural conditions of the rivers, lakes and streams of the State; to protect navigability of public bodies of water; and to protect all rights and interest of the People of the State (public trust).

4.2.7 National Environmental Policy Act

Section 102 of this Act requires federal agencies proposing major actions significantly affecting the quality of the environment to submit to the President's Council on Environmental Quality (CEQ) an Environmental Impact Statement (EIS) for such actions. This statement shall address the following:

a. The environmental impact of the proposed action.

b. Any adverse environmental effects which cannot be avoided should the proposal be implemented.

c. Alternatives to the proposed action.

d. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.

e. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

The U.S. EPA believes that an Environmental Impact Statement is not required for actions taken under Section 311 of the Clean Water Act.

4.2.8 Hazardous Material Transportation Act

The Federal Department of Transportation does not require specific permits for PCB transportation. In fact, at this time, PCBs are not even listed as a hazardous substance for purposes of regulation by DOT. However, new extensive regulations have been proposed and can be found at 45 Fed. Reg. 34560-34707 (May 22, 1980), but will not become final for an indeterminate period of time.

The new standards will update regulations found at 40 CFR 171-177, and represent the efforts of DOT and EPA to combine voluminous agency requirements. The hazardous material table found at 172.101 in the proposed regulations lists PCBs and provides applicable information regarding their transportation, inclusive of packaging requirements per Section 173.510. Shippers of hazardous substances are being notified by the government of the new standards and will be responsible for compliance.

4.2.9 City of Waukegan Construction and Electrical Permits

Construction permits must be obtained from the City of Waukegan for all work performed. Any electrical work performed on the site will require an additional permit.

5.0 EVALUATION OF ALTERNATIVES FOR NORTH DITCH CLEANUP

5.1 Excavation

In this alternative, all soils containing greater than 50 ppm PCB are considered for removal and then either landfilled in a secure site or incinerated. However, areas of contamination greater than 20 ppm are included for additional reference in Figure 3.. The depth of contamination varies from about one foot to 25 feet. Mason & Hanger estimates roughly 160,000 cubic yards of material must be excavated to remove PCB contamination greater than 50 ppm. Perhaps another 20,000 cubic yards will be required to remove everything greater than 20 ppm PCB. Not enough information is known to finitely define the boundaries of the contamination. Therefore these yardage estimates are only accurate to an order of magnitude.

The contaminated soils are mostly sandy or sandy fill and are of glacial origin. Ground water is only a few feet below the surface. There is a slow net water movement towards Lake Michigan. The North Ditch contains some muck sediments with high PCB concentrations which could be conveyed to Lake Michigan during periods of high runoff. At the plant outfall, the PCBs have sunk downward through the sand down to the underlying clay layer.

Excavation is not without difficulty. Several problem areas and proposed solutions are listed below:

1. Problem: PCB contamination is below the water table in many locations.

   Solution: Well points will have to be constructed to lower the water table level to permit excavation under dewatered conditions. A slurry wall will have to be constructed down to the silty clay where deep excavation is required as in the case of the Crescent Ditch and (probably) the Oval Lagoon portions of North Ditch and part of the parking lot near bore hole B15. The ground water removed should be treated with sand and carbon filtration before discharge.

2. Problem: Excavation in the North Ditch channels will roil sediments.

   Solution: The highly contaminated portions of North Ditch should be bypassed so that excavation can be performed in a dewatered condition. Mason & Hanger suggests bypassing the Crescent Ditch and Oval Lagoon portions entirely with a large reinforced concrete pipe; this pipe would run down the E-W portion of North Ditch to Lake Michigan.

3. Problem: The zone of contamination at the OMC outfall extends deep, to 25 feet; excavation may endanger nearby buildings.

Solution: A structural slurry wall is proposed for the Crescent Ditch portion. The wall will be braced from side to side for lateral stability. At this time, Mason & Hanger assumes that deep contamination does not exist at a distance closer to the buildings than 30 feet from the Crescent Ditch. If deep contamination extends further, perhaps under the buildings themselves, then either the buildings will have to be removed or the PCBs will have to be chemically-fixed in place as in Section 5.2. Limited core borings indicate that this is not the case and that all deep contamination can be removed while protecting the integrity of the earth beneath the structures with a slurry wall.

4. Problem: Opening up large areas of North Ditch could potentially result in large quantities of PCB being volatilized into the air or solubilized into rain water.

   Solution: The North Ditch excavation will have to proceed in phases with only a small portion of contaminated PCB soils exposed at any one time. Rainwater contacting contaminated soils should be collected and treated in the same way that groundwater will be treated. The excavated more-highly contaminated soils may have to be covered with tarps, plastic sheeting or organic material to minimize volatilization of PCBs into the air.

The sloped banks and shallow water depth in the E-W portion of the North Ditch suggest the use of small shovels, front end loaders, small draglines, or small bucket dry land excavation equipment, provided the ditch can be dewatered in short sections during excavation. Excavation should avoid damage to the existing steel sheet pile bulkhead wall along the north side of the ditch.

5.2 In-Place Destruction

To be effective, the agent causing the destruction of PCBs (whether chemical, thermal, or biological) must be well dispersed throughout the area of contamination. The North Ditch zone of contamination is broad, affecting possibly 160,000 cubic yards of soil, and is not all in one location. There is no proven agent that can be mixed or dispersed in the soil to insure destruction of PCBs that would not potentially result in harm to the environment.

The PCB destruction processes developed by Goodyear or Sunohio, for example, can only destroy liquid PCBs or PCB-contaminated solvents. They are not applicable to contaminated soils or watery-sludge. It is not practical to extract PCBs from 160,000 cubic yards of soils using an organic solvent such as hexane or hexane-acetic acid, and sending the solvent to a Goodyear or Sunohio process. It is also not practical to contact soils with a polyethylene glycol-sodium mixture, for example, because of the large volume involved.

Further discussion of in-place destruction is presented in Section 6.1.

5.3 In-place Fixation

Chemical fixation of sludges and soils is a proven method of containment for many classes of hazardous waste. Fixation agents such as portland cement, lime, sodium silicate, and/or certain polymers are mixed or injected into the sludge or soil. The material becomes like concrete or a loose aggregate.

The Takenaka Kamuten Co., Ltd in Japan has successfully used chemical fixation for in-place stabilization of PCB-contaminated sediment and soils since 1973, with no significant PCBs are reported to be leached from the fixed material. Proprietary chemicals and cement would be injected into holes at close intervals using an auger if the Japanese technology is applied at North Ditch. TJK, Inc. of Hollywood, California, who is licensed to provide the technology in the U.S., estimate very roughly costs of $20 or $30 per cubic yard to turn the soils into a concrete-like material plus costs to bring in injection equipment from Japan.

Mason & Hanger favors excavation in lieu of in-place fixation. Excavation would remove the contaminated materials whereas the PCBs would still be in the North Ditch area with in-place fixation. Very little is known about the long term stability of the concrete material formed. Eventually, the concrete will deteriorate, perhaps 50 or 100 years in the future, possibly releasing the PCBs. If contamination is deep and seems to penetrate under a building thus making excavation infeasible, chemical fixation may be a viable method of local containment, but should not be considered as a solution for the entire area.

5.4 Dredging

Battelle, Pacific Northwest Laboratories, recommended removing North Ditch contaminated sediments using a Mud Cat dredge. Since Battelle made their recommendation to EPA, extensive PCB contamination has been discovered under the OMC parking lot, areas east of the parking lot, the areas bordering the Crescent Ditch and Oval Lagoon, and in the Crescent Ditch down to 25 feet deep. Because of the very broad area of contamination, Mason & Hanger recommends that all areas be excavated as opposed to excavating some areas and dredging other areas. Dredging as an alternative could only remove the top loose muck sediments in North Ditch. A lagoon or holding basin would have to be built to hold the excess water or the watery material would have to be trucked to another location. Project logistics and costs would be less if all areas were excavated and North Ditch water is bypassed.

5.5 In-Place Secure Storage

The PCB contaminated soils now underneath the OMC parking lot and areas east of the parking lot are in a sense "in-place" storage. However, this storage is not "secure" because PCBs can be transferred via groundwater into Lake Michigan and surrounding shore areas. "In-place secure storage" means that the contaminated soils must be isolated such that PCBs cannot be transferred to the environment via the groundwater, volatilized in the air, or washed into Lake Michigan. Federal and state guidelines for landfilling PCB wastes would have to be followed for the design of secure storage facilities.

The EPA guidelines for an Annex II landfill, which would probably be the minimum requirements for long term storage, are described in 40 CFR paragraph 761.41 (Federal Register May 31, 1979 Page 31553). Among other requirements the landfill must be lined with at least three feet of clay, have a leachate collection system and have monitoring wells. Two requirements, namely (1) proximity to Lake Michigan and (2) fifty feet or more above the ground water, would have to be waivered by the EPA regional administrator if North Ditch in-place secure storage is to be considered as an Annex II landfill for hazardous waste. Additionally, there are two other important considerations affecting in-place secure storage on the OMC site. One is the long-term instability of the adjacent Lake Michigan shore line, which has historically been dynamic due to the sandy nature of the shore materials. Secondly, the 1957 flood of record completely submerged the areas surrounding the crescent ditch and oval lagoon of the North Ditch, and floods of this nature could in the future threaten the security of long-term storage on the site.

The Illinois EPA has suggested 10 feet of clay having a permeability coefficient of 10^{-8} cm/sec or less for a secure landfill for permanent storage of PCB-contaminated solids. This is more restrictive than the federal EPA requirement of 3 feet of clay having a permeability coefficient of 10^{-7} cm/sec or less.

Membrane or synthetic liners by themselves do not qualify as a barrier for in-place permanent storage even though such membranes may have a permeability coefficient several orders of magnitude less than clay. No manufacturer will guarantee such liners for more than a decade or two at the most. The barriers will have to hold for hundreds of years.

Perhaps the most logical location for an on-site permanent storage facility is under the OMC parking area north of the OMC buildings and south of North Ditch (E-W portion). An overall area 1700 feet long and 330 feet wide would be required to store the 160,000 cubic yards of North Ditch soils, plus 170,000 cubic yards of Waukegan Harbor contaminated sediments, with approximately 25% excess capacity. The facility should be constructed to comply with U.S. EPA and Illinois EPA requirements (waiver necessary because of proximity to Lake Michigan and groundwater). A slurry cutoff wall should be constructed around the perimeter of the facility to allow dewatering during construction; the wall should extend down to the underlying silty clay. The water removed must be treated to remove PCBs before discharge. The contaminated PCB soil already under the parking lot would have to be removed and temporarily stockpiled while a portion of the disposal area is readied for use. The slurry wall should be backfilled with an impermeable clay mixture. The base of the facility would extend approximately 30 feet below ground elevation; it would be lined with 5 or 10 feet of recompacted clay imported to the site. A leachate collection system embedded in gravel would be sandwiched in the clay liner; the collection system would lead to manholes for pumpout. The facility would be maintained as a dry system with leachate perodically removed from manholes and sent to a permanent water treatment facility for PCB removal. There would also be groundwater monitoring wells to measure background water quality.

The disposal facility would be capped with at least 3 feet of clay and surfaced with bituminous pavement or concrete. The final cover would be such to permit the return of the area to parking lot use.

In-place secure storage is, therefore, not an alternative to excavation or other alternatives discussed in this section, but a final disposal alternative. Contaminated soils must still be excavated to be put in secure storage. Final landfill site locations are evaluated more fully in Section 9.0.

5.6 Incineration vs Landfill of Excavated Soils

North Ditch area PCB-contaminated soils can either be incinerated or placed in a suitable landfill designed to contain PCB wastes. If incinerated, the residues may be typically 85 percent by weight of the original material since the contaminated soil is mostly sand. Incineration is attractive as opposed to landfilling because the PCBs (at least in theory) would be destroyed.

The incinerator used for incinerating PCBs must satisfy the requirements of 40 CFR paragraph 761.40 which includes (1) approval by the EPA Regional Administrator; (2) maintenance of a temperature of 1200°C (2192°F) and 2 second dwell time in the secondary combustion unit and 3 percent excess oxygen in the stack gas; or (2A) maintenance of a temperature of 1600°C (2912°F) and 1.5 second dwell time in the secondary combustion unit, and 2 percent excess oxygen in the stack gas; and (3) a combustion efficiency of 99.9 percent or greater. There are other requirements, especially in regard to monitoring. The EPA Regional Administrator can grant a waiver from meeting some of the requirements. Approval must also be ontained from the state agency.

As of December 1980 no incinerators for commerical use have been approved for PCB incineration in the United States. The status of existing PCB incinerators are listed below:

1. ENSCO, El Dorado, Arkansas (commercial)

   a. Capacity is limited to 600 lbs PCB/hr (by regulation) or about 3 cubic yards of solids per hour whichever is less.

b. Secondary combustion unit temperature is 2200°F and 4.5 second dwell time.

c. All ash must be sent to a hazardous waste landfill (by Arkansas regulation).

d. Costs could run $400,000 or $500,000 for incinerating 100 cubic yards of solids, of which most of the cost is for monitoring and ash disposal.

e. EPA Region VI (Dallas) has not approved this incinerator but is expected to do so pending examination of pilot test results.

2. Rollins, Deer Park, Texas (Commerical). This incinerator has not yet been approved by the EPA Regional Administrator.

3. Tennessee Eastman, Kingsport, Mass. (private). Accepts on-site wastes only.

4. General Electric, Pittsfield, Massachusetts and Waterford, N.Y. (private) Accepts GE wastes only.

5. MB Associates, San Ramon, California. MB Associates under EPA contract designed and constructed a mobile field use incinerator for the Oil and Hazardous Material Spills Branch, Edison, N.J. This incinerator has not yet been demonstrated as of January 1981.

Two manufacturers offer large incinerators capable of burning PCB-contaminated solids. They are as follows:

1. Nichols/Herreshoff multiple hearth furnace (Nichols Engineering and Research Corp., USA). The large capacity unit can process about 40 cubic yards per hour.

2. Von Roll rotary kiln (an European incinerator marketed in the USA by Koppers Co.). The large capacity unit can process about 60 cubic yards per hour.

Prenco, Inc. of Madison Heights, Michigan manufacturers a much smaller capacity incinerator which is currently being prepared for a test burn.

Nichols Engineers and Research Corporation, Bellemeade, N.J., has reported a successful test burn on Hudson River PCB-contaminated dredge spoils were PCB in the stack gas and ash residue was reduced below detectable limits. The secondary combustion temperature was 1800°F (982°C) for a dwell time of 5 to 7 seconds. Operation much in excess of 1800°F is not recommended by Nichols due to the formation of exessive NO_x. The NO_x is not readily absorbed in scrubber water at stack concentrations below several hundred parts per million unless the absorbing solution is chilled water and/or is made basic. The costs of such scrubbing equipment would be significant.

The Von Roll unit can maintain a temperature of 1,350°C (2462°F) for 3 seconds according to the manufacturer. Again, excessive NO_x will be formed at temperatures in excess of 1,800!F.

Mason & Hanger recommends that the U.S. EPA Regional Administrator give serious consideration to reducing the temperature requirements in the volatilization section and secondary combustion section to 900°F and 1,800°F respectively, and increase the dwell time in the secondary combustion section to 4 seconds.

Mason & Hanger estimates that direct operating costs for incineration exclusive of NO_x removal equipment should be slightly in excess of $40 per cubic yard (cost includes fuel oil at $1.00 per gallon, electricity, HCl scrubber water neutralization, and an $18 per cubic yard labor cost). These costs do not include permitting costs, monitoring costs, amortization costs, contractor overhead and profit, final residue disposal costs, or transportation costs. These other costs are difficult to estimate, but ENSCO, Ed Dorado, Arkansas has indicated that the permitting and monitoring costs required of government agencies to insure compliance can easily exceed direct operating costs. Mason & Hanger believes that when other costs are factored in, the total incineration costs could easily exceed $100 per cubic yard. Landfilling costs (to be disucssed in Section 9) are generally less than $100 per cubic yard depending upon the location.

Despite the environmental advantage of PCB destruction by incineration, Mason & Hanger recommends at this time that incineration of PCB-contaminated materials not be considered and landfilling be used as the method of choice for ultimate disposal of contaminated material. Landfilling is less costly than incineration when compliance to all regulations are considered.

If incineration is to be further considered, for example if no landfill site is available, Mason & Hanger suggests the use of a mobile field incinerator for an on-site test burn in order to verify conditions and evaluate costs, including whether PCBs can be completely destroyed at 1800°F and 5 to 7 second dwell time in the secondary combustion unit.

5.7 Recommendations

Mason & Hanger recommends the following:

1. A bypass around the highly contaminated portions of the North Ditch should be incorporated to reduce as much as possible the further migration of PCB's into Lake Michigan from surface water runoff.

2. Excavation is the most logical means for removing the North Ditch contaminated soils and sediments These soils should include the soft muck in North Ditch; the contaminated sand underneath the muck; contaminated sand and silty clay beneath the plant outfall and contaminated soils around the OMC buildings, North Ditch, parking lot, and areas east of the parking lot, all shown on Figure 4.

3. Before excavation can be started, provision must be made for disposal of soils in an EPA spproved site.

4. Slurry walls should be constructed to prevent intrusion of ground water. This will allow excavation to be performed in a dewatered condition. Well points will also be required to lower the water table level.

5. The project should proceed in stages or phases to minimize exposure of contaminated soils to the air and rainwater at any time.

6. All leachate water, well water, and rainwater collected ould be treated for PCB removal prior to disposal.

6.0 EVALUATION OF ALTERNATIVES FOR WAUKEGAN HARBOR CLEANUP

6.1 In-Place Destruction

6.1.1 Biological Methods

The limited work using biological agents (microbes, worms, etc) to destroy PCBs has been confined to the laboratory or small pilot plant applications. Assuming a suitable agent is developed which converts PCBs to innocuous residues, the agent would still have to be dispersed throughout the contaminated muck layer throughout the entire harbor at all depths. The agent would have to be adaptable to the environment and not die off until after the PCBs are consumed; the agent should not leave pockets of unconsumed PCB. The agent must not enter the food chain allowing PCBs to accumulate in fish. The agent must consume all types of PCBs including the most highly-chlorinated PCBs. The agent must not adversely disturb the ecology of the area. These problems have not been solved. Therefore in-place destruction using biological agents was not seriously considered as an alternative.

If the harbor is dredged and the contaminated dredge spoils transferred to a lined lagoon, perhaps biological agents can be tested within the confines of the lagoon. Extensive preliminary pilot plant tests should be completed including PCB volatilization measurements before EPA approval is given for testing in the lagoon. Precautions must be taken to insure that excessive PCBs are not volatilized as considerable aeration could be required to assist biological agents in the destruction of PCBs.

An article in a Waukegan newspaper (The News-Sun, November 10, 1980) carried comments of Mr. R. Laing, President of Clean-Flo Laboratories, Inc. a Hopkins, Minnesota firm, who claims to have mutant bacteria capable of destroying Waukegan Harbor PCBs in situ. The microorganisms were developed by Dr. Howard Worne of Bioferm International in New Berlin, New Jersey. Testing has been limited to relatively small plots. The organisms require aerobic conditions to grow and consume PCBs, and injections of ammonium phosphates and perhaps kerosene (10 lbs of kerosene per pound of PCB) into the soils or sediments may also be required. Mr. J. T. Wilson, Microbiologist for RSKERL, Ada, Oklahoma, commented that inoculations (into Waukegan Harbor sediments) would "almost invariably fail because the inoculated organisms are not preadapted to that particular environment and are destroyed by predation and competition from indigenous microbes". Anerobic conditions are almost certain to exist, especially where contamination is deep. Any attempt to aerate the sediment would result in excessive release of PCBs into Waukegan Harbor and volatilization into the air.

6.1.2 Chemical Methods

None of the chemical methods developed by various groups are adaptable for in-place destruction of PCB-contaminated sediments or soils.

For example, the Goodyear Tire and Rubber Company process is limited to the destruction of PCB liquids or PCB-contaminated oils. It is not adaptable to detoxification of solid materials or aqueous material from the harbor.

The PCBX process develped by Sunohio, Canton, Ohio, can be placed in trailers and moved to the site. However, the process is limited to destruction of PCB liquids and is not adaptable to destruction of PCB contaminated dredge spoils nor can it be used to destroy PCBs in situ.

PCBs can be extracted from contaminated dredge spoils using hexane or hexane-acetic acid mixture, or similar organic solvents. These solvents obviously cannot be used on the harbor sediments in situ. Even if the sediments are removed, the sediments would have to be thoroughly mixed with the solvents to extract the PCBs. The extraction procedure is not readily adaptable because of the very large volume of dredge spoils involved. The UV-Ozonation process for PCB destruction, demonstrated by Westgate Research, Inc. of San Diego, California, is not adaptable for treating large volumes of sediments.

6.2 In-Place Fixation

The Takenaka Komuten Co., Ltd., of Japan has developed a process (Takenaka Sludge Treatment System or TST system) for in-place stabilization of contaminated sediments. The process, used in Japan in 1973, involved pumping a 20 percent (wet basis) slurry of portland cement and proprietary additives through a pipe into the contaminated sediments. This is done at many harbor bottom points until the entire sediment bed becomes a series of vertical columns stacked side by side. The columns are rigid enough to serve as a foundation for construction projects (demonstrated in Japan). The PCB-contaminated sediments would be fixed in place as they would essentially become like concrete. If lower dosages are used, the sediments become less like concrete and more like a loose aggregate.

There are disadvantages to this method. The PCBs would still remain in the harbor. Long term stability of fixed sediments is not known as the process was first used in 1973, but significant PCB migration has not yet occurred from chemically-fixed sediments in Japan. The process would interfere with harbor biota. The harbor depth could be increased or channel widened only by blasting or rock cutting because of the "rock-hard" bottom. There would be problems of future dredging of sediments which may be washed into the harbor because the concretized bottom could damage dredge cutterheads or break other sediment dislodging devices. Therefore Mason & Hanger does not recommend chemical fixation of PCBs as a method for decontaminating the entire harbor.

In-place fixation may still be a viable alterantive for the deep contamination into the sand and clay in Slip #3 after the top muck layer is dredged. The purpose of the in-place fixation would be to put a cap on the PCBs which cannot easily be removed by other methods. Mason & Hanger still favors dredging and excavation of PCB-contaminated materials.

If PCB contamination has migrated extensively under the piling, and excavation cannot be done without endangering Larsen Marine structures, then Mason & Hanger may recommend chemical fixation of PCB contamination near the endangered buildings. More core borings are necessary to define the extent of contamination before a decision can be made. Concerned public officials may still require excavation and removal of all PCBs even if chemical fixation is a viable option.

TJF, Inc. of North Hollywood, California, who is licensed to provide the Japanese technology in the U.S., estimated that 5000 cubic yards of PCB-contaminated sand could be chemically fixed in situ at a cost of roughly $20 to $40 per cubic yard plus additional costs ($25,000 to $40,000) for equipment rental and transportation to and from Japan. The equipment uses an auger to inject the chemicals into the sand. There would be turbidity increase in the water associated with the operation, which would require use of barriers.

6.3 Dredging

6.3.1 General Comments

Dredging is a proven alternative which can remove PCB-contaminated sediments from Waukegan Harbor. However, care must be taken to minimize dispersal of PCBs during the dredging operation. Figure 12 illustrates a dredging concept. The lagoon in Figure 12 is described in Section 8 of the report.

The dredge is usually mounted on a vessel, a hull or a barge which would float the digging device above the material to be removed. Mechanical dredges include dipper dredges, ladder or continuous bucket dredges, and wire line dredges for deploying orange peel and clamshell or drag buckets. Hydraulic suction dredges use the motion of water to convey the sediment material, and pneumatic dredges employ hydrostatic pressure and vacuum to convey the material. Some latitude is required in the selection of the dredging method in the Waukegan Harbor depending upon location. For example, the Slip #3 area represents the greatest PCB concentration, the shallowest depth and the greatest restrictions for maneuvering. The harbor area from Slip #3 toward Slip #1 contains less PCB, is deeper and open so that a boat could more easily maneuver. From Slip #1 to the mouth of the harbor there is deeper water with less PCB concentration. There is commercial as well as small boat traffic and the U.S. Army Corps of Engineers maintains the channel where commercial traffic is involved. Dredging from Slip #3 may have to be done from shore (both sides).

There is concern that storms caused by normal water level variations can create a flow into and out of the harbor causing the PCB material to be dispersed into Lake Michigan. There is a steel sheet pile bulkhead or fender throughout the harbor boundary which could be damaged if an improper dredging technique is employed. Weather phenomena such as seiches have on occasion created 4 foot differences in water level. Slip #3 is the base for a marina and contains boat hoists, berths, gang docks and related marine facilities which will require removal or replacement if floating dredges are used due to the restricted

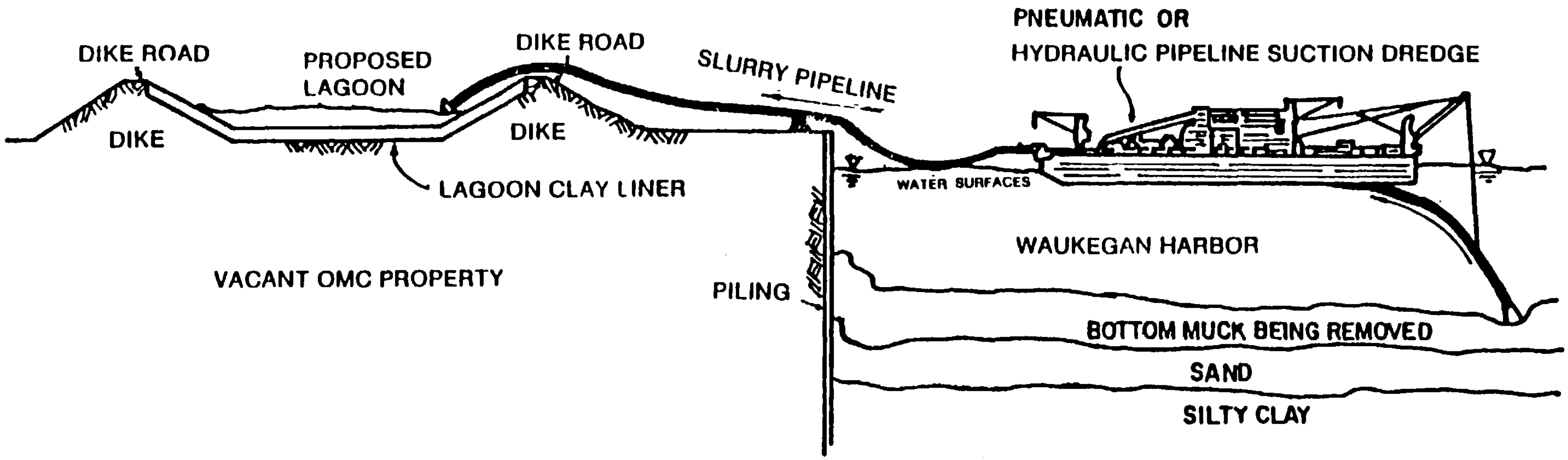


FIGURE 12

DREDGING OPERATION – WAUKEGAN HARBOR

NO SCALE

area. The area is also small enough that a long boom land based crane could clean most of the bottom, with minimum removal of marina facilities, using a hydraulic or pneumatic dredge head. These dredges, however, will not remove PCB in relatively-hard sand or clay. This type of material is normally removed by a cutter head dredge.

The criteria for minimum roiling of sediments so as to reduce uncontrolled release and spread of PCB when dredging very nearly eliminates all but pneumatic dredges or hydraulic dredges. Spuds to control or advance the dredges will roil more material than would on shore anchors or tie-offs. The pneumatic dredge seems best for removing muck; the equipment would operate from shore in Slip #3 and use a hull or barge for the remainder of the harbor. Mason & Hanger suggests a demonstration on less-contaminated sediments before selecting the dredge to be used in Slip #3.

Silt curtains are recommended. The silt curtain must be carefully designed to have strength, to allow water recharge from the deficiency caused by dredging and it must be "vented" to reduce the forces resulting from storm conditions.

Procurement of suitable pneumatic or hydraulic dredging equipment should not be difficult within a radius of 500 miles from Chicago, with the possible exception of the Japanese Oozer. If the Oozer dredge is mounted on a Japanese hull, is of Japanese registry and is manned by a Japanese or foreign crew, it is forbidden until registered or documented as a vessel of the USA (46 USC 292). If this were the case, it would probably be very difficult, if not impossible, to obtain the right to dredge Waukegan Harbor. However, an exception might be made if the Japanese dredging equipment only is mounted on a vessel or hull having USA documentation and is operated by an American crew. This would probably also be applicable if it were mounted on shore.

6.3.2 Comparison of Types of Dredges

6.3.2.1 Mechanical Dredges

Mechanical dredges include clamshell, dipper, dragline, and bucket chain dredges. A digging mechanism scoops up the bottom sediment and brings it to the surface where it can be placed in barges, in waiting trucks on the shore, or in piles along the shore. A clamshell dredge would probably be the method of choice if there was no concern for dispersal of PCBs, turbidity, or removal of all of the sediments.

Unfortunately, there is considerable disturbance and suspension of sediment when the digging mechanism enters the sediment. An estimated 15 to 30 percent of the muck sediment may be lost when a clamshell dredge lifts the muck out of the water; losses up to 50 percent may occur in deeper water. Some clamshell dredges have watertight buckets which are reported to result in a 30 to 60 percent reduction in turbidity. However, even a watertight bucket dredge can have debris caught in its jaws and cause release of dredged muck upon ascent.

If too much turbidity is released when dredging Slip #3, considerable PCBs will solubilize, possibly exceeding 50 ppb or 100 ppb soluble PCB in water. If this happens, large dosages of powdered carbon may be required to remove soluble PCBs. The dredge may have to go back over the site to remove the settled carbon.

Therefore, Mason & Hanger, while not excluding mechanical dredges, prefers the use of hydraulic or even pneumatic dredges in order to minimize roiling of sediments.

6.3.2.2 Hydraulic Dredges

The hydraulic dredge uses a suction line, a centrifugal suction pump, and a discharge line which normally rests on a series of pontoon floats. The discharge line can also be submerged under water to allow passage of boats. However, given a choice, Mason & Hanger does not recommend submergence because of maintenance problems (line may plug). The discharge line can be extended to any desired length, and booster pumps can be used to assist the on-board centrifugal pump for pumping greater distances. The Waukegan Harbor bottom muck is ideally suited to the use of the hydraulic dredge. Turbidity is considerably less than mechanical types as both water and bottom solids would be conveyed. Any sand dredging in Slip #3 would require a cutterhead or alternative device at the dredge head to loosen the material.

The hydraulic dredge will require a receiving basin for the sediment slurry. Mason & Hanger recommends a temporary lagoon(s) or pond(s) be constructed to receive the dredged slurry. The excess water is then withdrawn, treated for PCB removal, and returned to the harbor. The dewatered dredge spoils would then be landfilled or disposed in some other manner.

The dredge spoils and slurry water can also be transferred to waiting barges or tank trucks and hauled to a distant site, but construction of a dewatering lagoon and water treatment facility would still be required at the receiving end. There would be considerable public oppostion against constructing a treatment facility at another location as dredged slurry and liquids are more hazardous than solids. There would also be considerable risk in spillage of PCB-contaminated water during loading and transit. The expense of transporting the extra slurry water would be several times that of hauling dewatered dredge solids alone. Therefore, economics suggest dewatering and removing the excess solids on site before transporting to a distant location.

The hydraulic dredges available differ in the design of the cutterhead and mechanism of positioning the dredge heads and generally fall into the following categories:

1. Dustpan suction
2. Conventional rotating basket cutterhead
3. Horizontal rotating cutter
4. Specialized rotating cutter.

Dustpan suction dredge heads should be able to remove the muck sediments which are loosely consolidated with very little turbidity. Horizontal rotating cutterheads are suitable for dredging sand with a minimum of turbidity; this type of dredge head is equipped with a shroud partially covering the cutter mechanism to lessen turbidity. The conventional rotating basket cutterhead can cut through both the sand and hard compact clay material in Slip #3, but can generate more turbidty than the other dredge types.

Selected hydrualic dredges offered by various manufacturers and distributors are listed in Table 3. This is not an exhaustive list.

There is a possiblity that two types of dredges will be required, one to remove the muck sediments with minimum turbidity and another equipped with a cutterhead to remove contaminated sand in Slip #3.

6.3.2.3 Pneumatic Dredges

Pneumatic dredges use hydrostatic pressure to fill submerged chambers with sediment and then compressed air to force the sediments through a discharge pipe from the chamber. Potentially less water is conveyed with the sediments than a hydraulic dredge, and low turbidity is maintained.

A typical pneumatic dredge has a dredge head with two or more large steel chambers with a sediment intake opening at the bottom end. Each chamber has two pipes entering the top, one for removing the sediment water mixture and another for introducing and releasing compressed air. When the dredge head is lowered to the bottom, hydrostatic pressure, possibly assisted with a vacuum pulled on the chamber, forces the sediment and water through an inlet pipe. When the chamber is full, the inlet valve is closed and compressed air is introduced through a valve at the top of the chamber. Air pressure acts as a piston to force the sediment and water through the discharge pipe. When the chamber is empty, the compressed air line is vented to the atmosphere, beginning the cycle again.

There would be some volatilization of PCBs into the atmosphere if a pneumatic dredge is used in Slip #3. The compressed air used in operation would contact the highly contaminated sediments and some volatilization would result.

There are basically two commercial pneumatic dredges available, one the Italian-designed Pneuma dredge and the other, the Japanese Oozer dredge. TJK, Inc. of North Hollywood, California is licensed to provide the Oozer dredge in the United States. Pneuma North

TABLE 3

COMPARISON OF SELECTED HYDRAULIC DREDGES
(not an exhaustive list)

Dredge Model No.	Manufacturer/ Distributor	Dimensions LxW (ft)	Draft (in)	Trans-port Width (ft)	Weight (lbs)	Dredge Head Type	Production Capacity (yd^3/hr solids)	Dredging Depth (min/max ft.)	Propulsion or Positioning System	Operating Dredge Pump Flowrate (gpm)
Waterless Dredge Model 8-180	Waterless Dredge Co. Mattoon, IL	33.5 x 12.5	18	8	23,500	(a)	150-200	0 to 16	(f)	2500 @ 90' head
Mud Master Dredge Model HPC-250 SM	Dredgemasters International Hendersonvill, TN	34 x 12	33	8	35,000	(b)	120-150	2 to 18	(g)	3000-4000
Mud Cat Dredge Model MC-915	National Car Rental System St. Louis Park, MN	39 x 9	21	9	21,000	(c)	120	2 to 15	(h)	2000
Delta Dredge Model 212	Delta Dredging Co. St. Louis MO	40 x 16	32	8	31,000	(d)	100-120	3 to 16	(i)	
Dixie Dredge Model CS-8E	Dixie Dredge Corp. St. Louis, MO	28 x 11	35	11	37,420	(e)	45-105	3 to 20	(j)	2000-3000
Ellicott Dragon Series Dredge Model 770	Ellicott Machine Corp. Baltimore, MD	42 x 21	36	10	148,000	(e)	450-550	4 to 27	(j)	Unknown
Eagle Iron Works 8 in. Cutterhead Dredge	Eagle Iron Works Des Moines, IA	46 x 18	24	10	85,200	(e)	115	3 to 30	(j)	2700
W&S Dredge Model D-24-1	W&S Development, Inc.	46 x 10	Unknown	10	30,000	(e)	140	3 to 20	(j)	2500

(a) = Two 4 ft. auger-type rotary cutters mounted one above the other, parallel to the ladder, and partially enclosed by a shroud.

(b) = Choice of conventional rotating cutter, horizontal auger, or dustpan suction

(c) = Twin horizontal augers with a total 9 ft. cutting width, partially enclosed by a shroud.

(d) = Dual horizontal, counter-rotating cutter discs.

(e) = Conventional basket-type cutterhead.

(f) = Cables, swing winches in various arrangements.

(g) = Choice of conventional spuds and swing winches, single cable and winch, or 4 corner winches and cables

(h) = Single cable and winch

(i) = Anchors and swing winches

(j) = Conventional spuds and swing winches

Information adapted from: U. S. Army Corps of Engineers, Mobile District
[illegible]

America, Libertyville, Ill. provides the Pneuma dredge. The Pneuma dredge has been successfully used to remove PCB contaminated sediments from the Duwamish Waterway, Seattle Harbor, Washington, with very low turbidity levels generated during operation. The Oozer dredge likewise has dredged contaminated sediments in Japan with low turbidity generation, and can be equipped with underwater television cameras at the head to visually monitor turbidity.

Both dredges are quite large and would have difficulty maneuvering from barges in Slip #3. Neither would be able to remove the underlying silty clay or compacted sand without a cutterhead or auger. Use of a cutterhead or auger would increase roiling of bottom sediments and the amount of water required to slurry the solids. Without a cutterhead or auger, the dredge could only be used to remove the muck sediment layer and possibly the top inch or so of sand. The Oozer dredge measures 82' by 33' (Japan) and the Pneuma dredge measures 40' x 20'. Slip #3 is 72' wide. If used in Slip #3, the dredge will probably have to be mounted on shore.

6.3.3 Minimizing PCB Dispersal During Dredging Operations

Careful selection of the proper dredge and care during the dreding operation can keep roiling of bottom sediments to a minimum.

No system is perfect, and some escape of turbidity will occur from the dredge head. Mason & Hanger suggests the use of a double silt curtain stretched across the harbor defining the area to be dredged. The double silt curtain would be attached to the sides of the harbor with pilings; weights and floats attached to the curtain would keep them in place across the harbor.

A silt curtain is not water tight. The curtain would bend or flex as required in response to waves and changes in water elevation, and water can flow past the curtain in either direction at the edges or splash over on the top and through slits or holes in the curtain.

A double silt curtain is more effective than a single silt curtain in containing turbidity. The space between the two silt curtains can serve as a buffer chamber to catch any material that may spill over. A cationic polymer can be used to flocculate and settle any turbidity that may spill over to the buffer chamber.

It is not possible to stretch a watertight membrane or curtain across Slip #3 or other parts of the harbor and expect it to remain intact during waves or seiches, even if the membrane is several inches thick and reinforced. If a watertight seal is desired, then a dam would have to be built across the area to be closed off or some innovative, and probably expensive, technique would have to be used.

The M. Putterman Co., Chicago, Illinois can design and fabricate a water-inflated dam shaped somewhat like an elongated egg or sausage. The ellipsoidal-shaped dam would be clamped to steel piles at the shore and would be weighted at the bottom to rest on the sand layer. The balloon-like sausage would be fabricated from KEVLAR-reinforced urethane rubber having a tensile strength of at least 1500 pounds per inch. The sausage when installed should withstand as much as several feet difference in water elevation on each side. Some of the sediments under the sausage would probably have to be removed so the sausage can form a reasonably tight seal against an even bottom. There would be some roiling of sediments when the sausage dam is put in place. The cost of the dam is expected to run about $12 per square foot; the cost of a 300 foot dam could be expected to run close to $400,000 before installation, about 8 or 10 times the cost of a double silt curtain.

When the dredging job is complete, the water behind the silt curtains should be tested for turbidity, total PCB, and soluble PCB. If necessary, a cationic polymer (approved for potable water treatment) solution can be mixed into the harbor to coagulate and settle turbidity. If necessary, powdered activated carbon slurry can be added (before adding the polymer) to remove soluble PCB; the polymer will help settle the carbon. The dredge can then vacuum up the settled solids.

Even if the entire harbor is to be dredged at one time, Mason & Hanger recommends that a double silt curtain be installed across Slip #3 to confine the most contaminated sediments, perhaps installed 400 or 500 feet from the west end, while Slip #3 is dredged. The water behind that silt curtain will probably have to be treated with powdered activated carbon and polymers after the sediments are removed.

6.4 In-Place Secure Storage

In this concept, the northern portions of Waukegan Harbor are sealed off. Sediments from the southern portion of the harbor are then removed using a hydraulic dredge and transferred to the upper portion of the harbor behind the sealed wall. The water in the upper portion of the harbor is removed, passed through a water treatment system (sedimentation, filtration, and carbon filtration) for PCB removal, and conveyed to the lower portion of the harbor. After the water is removed, the sediments in the upper portion are then capped with clay, synthetic liner, and top soil. The upper portion of the harbor would then no longer exist.

More specifically, a slurry wall would be placed around that portion of the harbor used as in-place secure storage. A dam would be constructed to separate the harbor used as secure storage from the rest of the harbor. The portion of the dam facing the harbor would be faced with steel sheet piling. The dam would be constructed such that it forms a continuation of the slurry wall.

PCB-contaminated sediments from the lower portion of the harbor would then be conveyed back behind the dam. The sediments are then stabilized by the Japanese TST system (Section 6.2). A water treatment system sized to approximately keep up with the dredging would treat the water displaced by the sediments. The dewatered sediments would probably be capped with (1) an organic rich material (2) about 3 feet of clay, and (3) top soil, asphalt, and/or concrete. The existing sand piles on OMC property containing low level PCB can be used as partial fill. Monitoring wells would be recommended to check migration of PCBs in ground water. Variations of this basic plan are possible.

The dam may have to be placed at the following approximate locations for removal of varying levels of PCBs: (See Figure 11 for location of A4, B1, B2 and B5).

PCB Removal Level (to be placed behind dam)	Dam Location
Over 500 ppm	Through A4
Over 50 ppm	Through B1 & B2
Over 10 ppm	Through B5

Order of magnitude costs for in-place storage, excluding roadways, permits, engineering compensation for lost use of the harbor and monitoring costs are listed below:

In-Place Secure Storage

Removal Level:	Over 500 ppm PCB	Over 50 ppm PCB	Over 10 ppm PCB
Silt Curtains	$ 50,000	$ 100,000	$ 100,000
Slurry Wall	100,000	175,000	500,000
Dam Costs	110,000	700,000	500,000
Dredging	100,000	300,000	900,000
Water Treatment	550,000	900,000	1,210,000
Fixation of Sediments	210,000	1,130,000	4,430,000
Fill material	60,000	140,000	670,000
30 percent contingency	350,000	1,030,000	2,500,000
Subtotal	$1,530,000	$4,475,000	$10,810,000
20 percent overhead and profit	306,000	900,000	2,160,000
Total	$1,836,000	$5,375,000	$12,970,000
say	($2,000,000)	($5,500,000)	($13,000,000)

This type of work is unprecedented so it is very difficult to estimate costs. Extensive tests will likely be required to prove to the public and governmental agencies that the PCBs will be secure as this alternative does not conform to an Annex II landfill (40 CFR paragraph 761.41; Federal Register May 31, 1979 Page 31553).

Mason & Hanger believes that this alternative is less desirable than dredging, dewatering, and landfilling or incineration for the following reasons:

1. The north end of the Harbor will no longer exist. Businesses such as Larsen Marine and possibly National Gypsum Company could be adversely affected. National Gypsum Company would probably not oppose closure of Slip #3. The northern end of the Harbor does have considerable recreational value. Any business adversely affected may seek compensation for their losses.

2. The PCBs will still remain. A convincing test program proving that the PCBs will be "forever" immobilized will be difficult and expensive if not impossible to develop. There could be delays in approval of the methodology. Proof of immobilization will be very difficult because the PCBs have penetrated the underlying silty-clay at the outfall.

3. If the decision is made to secure Slip #3 only, the contaminated material from the rest of the harbor cannot be put in behind the dam at a later date. A second dam would have to be built and more of the harbor would have to be blocked off which would increase costs.

4. There may be difficulties in minimizing turbidity, even using silt curtains, during the construction of the dam.

6.5 Draining Waukegan Harbor and Excavation of Sediments

In this concept, a dam is built across the harbor and the water behind the dam is pumped through a water treatment system back into the open end of the harbor. The exposed sediments are then excavated and hauled away to a landfill. The dam is then removed and harbor returned to its original condition minus PCB-contaminated sediments.

This alternative has several costly and complicated problems associated with it. When the water is drained from the harbor, for example, the sheet piling and adjacent shore would be adversely affected. A slurry wall would have to be constructed around the perimeter where excavation is to take place. Well points will have to be placed around the perimeter to prevent groundwater from refilling the harbor. A study would have to be made to determine whether water removal would endanger nearby buildings. The harbor would not be available for use during the period of excavation, which could exceed a year. There could be considerable volatilization of PCBs from exposed harbor sediments during excavation. Mason & Hanger, therefore, does not favor this alternative for the entire harbor.

Unfortunately, PCB contamination in Slip #3 near the outfall is deep. Mason & Hanger is of the opinion that contamination into the underlying sand and clay cannot be removed by dredging, even using a cutterhead, without endangering the shore sheet piling. If the sand should be removed by dredging, the piling (the tips of which seem to be embedded in sand rather than clay at many locations) may loosen and the shore collapse. Excavation is therefore a viable option for removal of the deep sand and clay near the outfall in Slip #3.

Mason & Hanger recommends more core borings near the outfall to better define the area of deep contamination. The top contaminated muck sediments should be first removed by dredging. A cofferdam - slurry wall arrangement should be built around the perimeter of the deep contamination. This cofferdam - slurry wall can extend onto the shore if PCBs have migrated under the sheet piling near the outfall. The water inside the cofferdam should be pumped out and over to the water treatment system which services the lagoons used to contain dredging spoils. The sand and clay should then be excavated in a dewatered mode. The contaminated material may be placed directly in trucks and hauled to a secure landfill or placed in a portion of the lagoon for later disposal. When the contamination is removed, the hole may be filled in with fresh sand or with the cofferdam material itself. This method would enable the deep contamination to be removed without spreading contamination to the rest of the harbor. The shore area would then be restored to its original condition.

6.6 Incineration vs Landfill of Dredge Spoils

Waukegan Harbor dredge spoils, after removal of excess water, can be either landfilled or incinerated. If incinerated, the residues (may be 50 percent of the volume of original material) left over will still have to be landfilled if they cannot be left on site. The residues may be used as fill elsewhere if the PCB content is 0.0 ppm.

The EPA ruling under 40 CFR part 761 (Federal Register May 31, 1979) permit dredge spoils (solids) of any concentration of PCBs to be disposed in a chemical waste landfill designed according to Annex II requirements stated in paragraph 761.41. Liquid PCBs in concentrations greater than 500 ppm must be incinerated. Liquid PCBs refer to oils or other organic solvents which contain PCB and does not refer to water which may contain highly-contaminated dredge solids; the water can be removed from the solids and PCBs removed from water with activated carbon filtration. Dredge spoils with bound water or with oily films are still regarded as a solid.

There may be small pockets of liquid PCB below the old outfall in the muck, sand, or clay. It is not practical to separate any liquid PCB from the rest of the sediment before starting dredging and excavation and any such liquid occlusions would become mixed with the rest of the solids during these operations. The EPA may wish to segregate all sediments directly below the OMC outfall and place in an Annex III type storage facility for later incineration if they contain a very high concentration of PCBs.

As of December 1980 no PCB incineration for commercial use has been approved by an EPA Regional Administrator. Two incinerators, one operated by ENSCO in Arkansas and the other operated by Rollins in Texas, are close to EPA approval pending examination of trial burns. The State of Arkansas has imposed a rule on the ENSCO incinerator requiring that all residues from PCB incineration be disposed in an approved PCB landfill. If the State of Illinois should require such a rule for any future

Illinois incinerator, incineration would offer no cost advantage. Incineration becomes a possible alternative only if the incinerator can be operated on-site and the residures left on-site. If the contaminated soils must be shipped to a distant location to be incinerated and if the residues must be placed in an approved PCB landfill, incineration offers no advantage. The current EPA regulation (40 CFR part 761.41) allows for disposal of PCB contaminated soils containing any concentraiton of PCBs to be disposed in an approved PCB landfill. It also states only liquids in excess of 500 ppm PCB should be incinerated. Incineration is further discussed in Section 5.6.

Despite the environmental advantage of PCB destruction by incineration, Mason & Hanger recommends at this time that incinceration of PCB-contaminated materials not be considered and landfilling be used as the method of choice for ultimate disposal of contaminated material. Landfilling is less costly than incineration when compliance to all regulations are considered.

If incineration is to be further considered, for example if no landfill site is available or if landfill disposal costs exceed costs for incineration, Mason & Hanger suggests the use of a mobile field incinerator for an on-site test burn in order to verify conditions and evaluate costs, including whether PCBs can be completely destroyed at 1800°F and 5 to 7 second dwell time in the secondary combustion unit.

6.7 Recommendations

1. Mason & Hanger recommends that Waukegan Harbor be dredged to remove PCB-contaminated muck sediments.

2. The dredged sediments should be transferred to a temporary nearby lagoon or holding basin, preferably on the OMC property, for removal of excess water, and the dewatered dredge spoils transferred to a secure landfill.

3. Silt curtains, preferably a double silt curtain, should be employed during dredging to confine turbidity. A silt curtain should also be placed across Slip #3 about 400 or 500 feet from the end even if the entire harbor is to be dredged at one time.

4. The current regulations indicate that all dredge spoils containing 50 ppm PCB should be either incinerated or placed in a secured landfill. Also, dredge spoils containing 10 to 50 ppm PCBs need not be placed in a secured landfill but in a location approved by the EPA Regional Director. Removal of sediments containing 50 ppm PCB or greater will remove a very large majority of the PCBs in the Waukegan Harbor. It is suggested that if funds are availabe the 10 to 50 ppm sediments could be dredged and dewatered in the lagoons.

5. The dredge should be selected on the basis of meeting performance specifications (minimum turbidity generation, removal of a maximum amount of contaminated sediments, avoidance of excess slurry

water which would place an undue burden on the lagoon size and slurry water treatment). This favors a pneumatic dredge as a first choice and a hydraulic dredge as a second choice.

6. More core borings are needed near the Slip #3 outfall to define the perimeter of deep contamination.

7. Upon completion of removal of the muck sediments in Slip #3, a coffer dam slurry wall arrangement should be constructed around the boundary of the deep contamination near the outfall. The water should then be pumped out, the water pumped over to the lagoon or holding basin used to receive dredge spoils. The deep contaminated sand and clay should be excavated in the dewatered condition. The dam should then be removed and Slip #3 restored to its original use.

7.0 EXCAVATION OF NORTH DITCH CONTAMINATED SOILS

7.1 Introduction

As discussed in Section 5 of this report, excavation of the North Ditch contaminated soils and placement in a final disposal site is the recommended method for their disposal. Mason & Hanger recommends this portion of the work be performed in several stages. Initially a bypass diverting the surface water flow around the highly contaminated portions (crescent ditch and oval lagoon) of the ditch should be constructed. This bypass should tie into a new storm sewer to replace the E-W portion of the North Ditch. The contaminated soils which are removed from performing this part of the work should be disposed as recommended in Section 9. Figure 13 shows a plan view of the proposed project. By bypassing the highly contaminaed portions of the North Ditch, the further spread of contamination from this area will be minimized.

When excavation of the highly contaminated sections of the ditch is begun, a slurry wall or other impermeable structure should be built to completely enclose these highly contaminated areas of excavation. The purpose for this will be to allow dewatering of the excavation site, and then final excavation with traditional earthmoving equipment. This also will allow testing of the soils for contamination during the excavation, thereby assuring that the contamination is removed with a minimum of excavation.

This section of the report will discuss in detail the plan and state the expected costs, time frame and special precautions required for performing this work. Figure 4 shows the contaminated portions of greater than 50 ppm of the North Ditch and surrounding areas. This discussion will assume the excavation will only be in those areas.

7.2 Bypass Around the Crescent Ditch and Oval Lagoon

Mason & Hanger recommends intercepting the storm sewer that now brings North Ditch surface water under the railroad track to the Crescent Ditch and diverting its flow into an underground storm sewer to carry this water all the way to Lake Michigan. The present discharge from OMC, located at the east end of the Crescent Ditch, will also be diverted from the ditch to the same underground storm sewer.

The existing 36 inch storm sewer that flows north at the west edge of OMC's property will be tied into a new storm sewer and will be directed to Lake Michigan by the shortest feasible route thru the E-W contaminated portion of the North Ditch. There are several existing smaller (about 12 inch) storm sewers that come from the northwest half of OMC's main building. These also will be diverted along with the 36 inch storm sewer flow to the new underground storm sewer. A small amount of surface area between OMC's building and the Crescent Ditch will remain without any existing surface water catch basins. New catch basins will be installed to collect this water and direct it to the 36 inch storm sewer extension. This plan would collect all surface water that now runs into the Crescent Ditch.

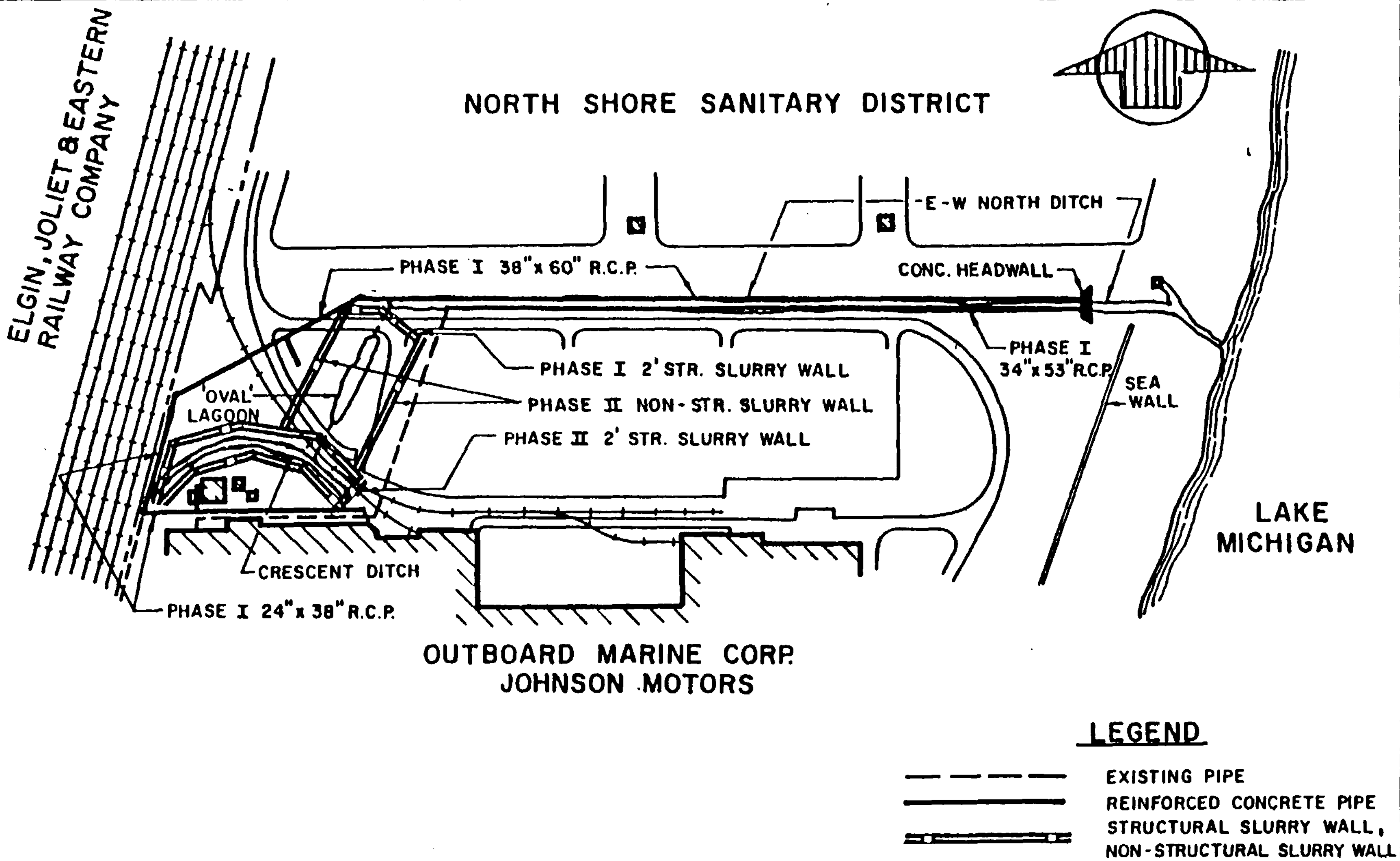


FIGURE 13: NORTH DITCH BYPASS (PHASE I) AND SLURRY WALL (PHASE II) PLAN

NO SCALE

NOTES: 1. FOR TYPICAL SECTION OF CRESCENT DITCH, SEE FIGURE
2. FOR TYPICAL SECTION OF OVAL LAGOON, SEE FIGURE

In order to collect the surface water runoff around the crescent ditch as described above, it will be necessary to excavate a portion of the southwest end of the ditch. It is assumed that if there is any PCB contamination in this area it will be so shallow that the excavation necessary to install the storm sewer will remove all of the contaminated materials. It is estimated that only about 220 cubic yards of contaminated material will be removed for this portion of the work. These materials will be combined with other contaminated materials for final disposal and will be replaced with new, clean material so that when the construction is complete the area where the new storm sewer is installed will be "clean".

The new storm sewer carrying the flow of the 36 inch storm sewer will be constructed to the point where it is just west of E-W part of the contaminated North Ditch. When construction is complete to this point, it will be necessary to block this new storm sewer and divert any water that it collects until the E-W North Ditch bypass is completed. Diversion will be by pumps placed in a manhole in the new bypass.

The plan then is to build in segments the new storm sewer (preliminary size 38 inch by 60 inch) to Lake Michigan while cleaning out the North Ditch. Excavated material will be replaced with new material. It is believed, based on sediment sampling analyses received to date, that the E-W ditch can be cleaned out to an acceptable level by removing two to five feet of material from the sides and the bottom of the ditch. This is estimated to consist of 7,000 cubic yards of contaminated material to be disposed of. It will be necessary to dewater as excavation progresses. This water is expected to be contaminated; therefore it will probably be necessary to treat it before disposal. This waste treatment system, if required, would also be available if it should be discovered that the dewatering of the previously discussed storm sewer installation yields contaminated groundwater. For the purposes of the plan, Mason & Hanger is assuming it will be required.

As the new storm sewer is installed in the North Ditch, it will be necessary to install a second storm sewer parallel to the 36 inch diversion. It will pick up any surface water from the existing parking lot and the remainder of OMC's building, and any of the effluents from OMC's building. These two storm sewers will be built simultaneously along the centerline of the E-W North Ditch until the entire bypass is completed.

When the bypass as described above is completed the area surrounding the two new storm sewers located in the E-W portion of the North Ditch will be "clean" and can be paved over as an extension of the existing parking lot if so desired. This work should provide removal of the contamination in this portion of the North Ditch and divert all flows proceding to Lake Michigan from passing through contaminated portions of the North Ditch.

7.2.1 Construction Considerations

The construction of the bypass should proceed rapidly to the point where work begins on excavation of the E-W ditch. Once the E-W ditch work is started, all surface water will be bypassed by pumping, thereby allowing work to proceed on the contaminated ditch. It is suggested that construction begin west to east as there are one or two storm sewers from OMC's building that must be picked up in the new storm sewer bypass as construction progresses. As construction progresses and these additional waters are picked up they will also be bypassed around the construction by pumping.

Because of the possibility that dewatering large areas of the ditch could cause settlement problems to the treatment plant and existing storm sewers just north of the E-W ditch, due to lowering of subsurface water elevations, the area of the contaminated ditch that is dewatered at one time will be held to a predetermined rather short length. Even using this procedure and allowing some delay for higher contaminated pockets along the ditch, the construction should be able to be completed before winter weather would cause a halt if the bypass construction was initiated in the spring.

7.2.2 Factors Affecting Construction and Design

1. Verification of contamination levels in the southwest end of the crescent-shaped ditch are needed to determine what portion of this area can be excavated to only a shallow depth.

2. Field determination to verify intended dewatering technique should be performed including some simple soils sampling and soils testing.

3. Verification of groundwater contamination to determine the requirements of a treatment system should be performed.

4. More detailed information on surface drainage of the areas west of the railroad is needed. This may entail a field or aerial survey.

7.3 Excavation of Contaminated Sediments and Soils in North Ditch

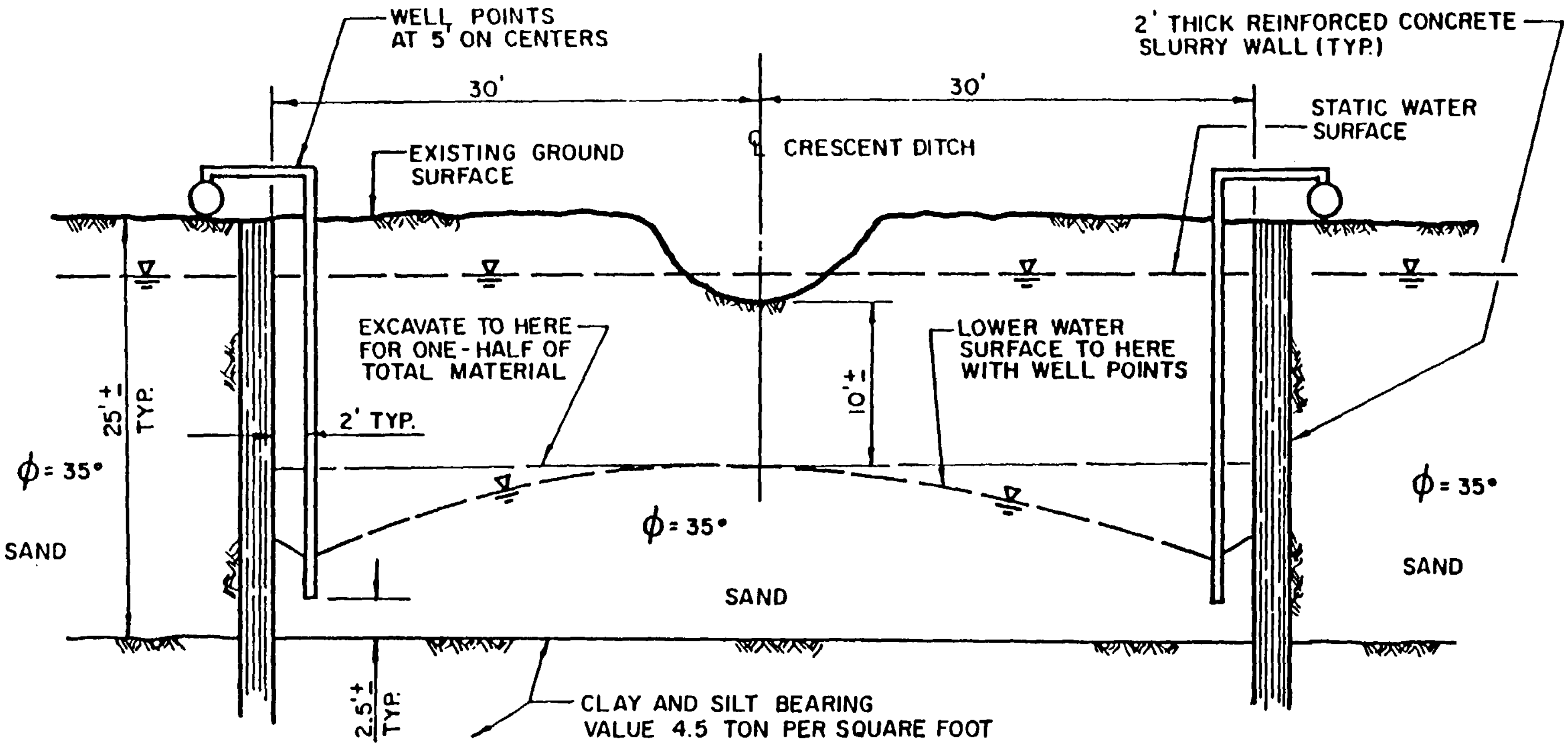
7.3.1 Description

When the first increment of the North Ditch cleanup of OMC property consisting of the Bypass in the E-W ditch is completed, the spread of PCB contamination from surface water runoff will virtually be eliminated. The only remaining way that PCB's could be further spread is by subsurface water movement and volatilization. Subsurface water movement is very slow; therefore, when surface water runoff is eliminated the only water available for movement of PCB other than subsurface water will be that rain water that falls directly on the remaining contaminated areas and residual PCBs in soils not removed. Because of the characteristics of the soil, any migration of PCBs laterally from either ditch will be very limited provided it is not allowed to continue over many years. The EPA is presently sponsoring a study to examine the potential of groundwater spread of the contamination. In addition, the present volatilization rate is believed to be low from those areas contaminated with PCB. Some volatilization measurements in the area are recommended. The elimination of the surface water entering the ditch affords time to plan a cleanup program in phases that can be accomplished as funds become available.

Before any exact description of the extent of the cleanup can be established, it will first be necessary to identify the extent of the contamination. The subsurface investigations performed to date indicate very high concentrations of PCB's as deep as 30 feet below the surface in the Crescent Ditch. Also, the water samples taken adjacent to the crescent ditch contain contaminations in excess of 35 ppm. This indicates that contamination has spread laterally from the ditch but there is not enough data available to determine a detailed concentration profile with depth and to each side of the ditch. Mason & Hanger recommends a detailed investigation be performed to more exactly define the limits of the contamination. This could substantially reduce the total quantity of soils to be removed.

Regardless of how the contamination has spread laterally, there are certain restraints that govern the practical limits of excavation of contaminated materials. These are the structures on the south side of the crescent ditch. In this location there are several buildings and a water tower and not too far away is the main OMC building. If the contamination levels under the building are higher than the allowable level, then a decision will have to be made whether or not to excavate under the building. Since excavation under the buildings could disrupt OMC's operations, consideration would have to be made of the extent of potential damages to the Company as opposed to the future effects of leaving the material in situ. For the purposes of this report, Mason & Hanger has assumed that the level of contamination under the buildings is at an acceptable low level and the only material to be removed can be excavated without disruption or damage to any buildings.

Mason & Hanger has performed a feasibility study for the practical limits of excavation on the south side of the Crescent Ditch which has resulted in two plans. One plan would allow the excavation of soils possibly 20 feet to either side of the ditch. The other would allow excavation to possibly 30 feet to either side of the ditch. Both would allow excavation to a depth of about 25 feet since there are analyses showing extensive contamination to this depth. The first plan is to build a cellular coffer dam type structure completely encircling the ditch. Since a cellular coffer dam will stand unbraced, it is necessarily wider than most other containment structures which limits the area for excavation between the coffer dams. The second plan is to build a slurry wall that can be braced from side to side for lateral stability. Figure 14 depicts this type of slurry wall arrangement. Either the coffer dam or the slurry wall would be as close to the existing structures, on the south side of the ditch, as is practical so as not to disturb the structures.



NOTE: 1. φ = ANGLE OF REPOSE

FIGURE 14: TYPICAL SECTION FOR CRESCENT DITCH

NO SCALE

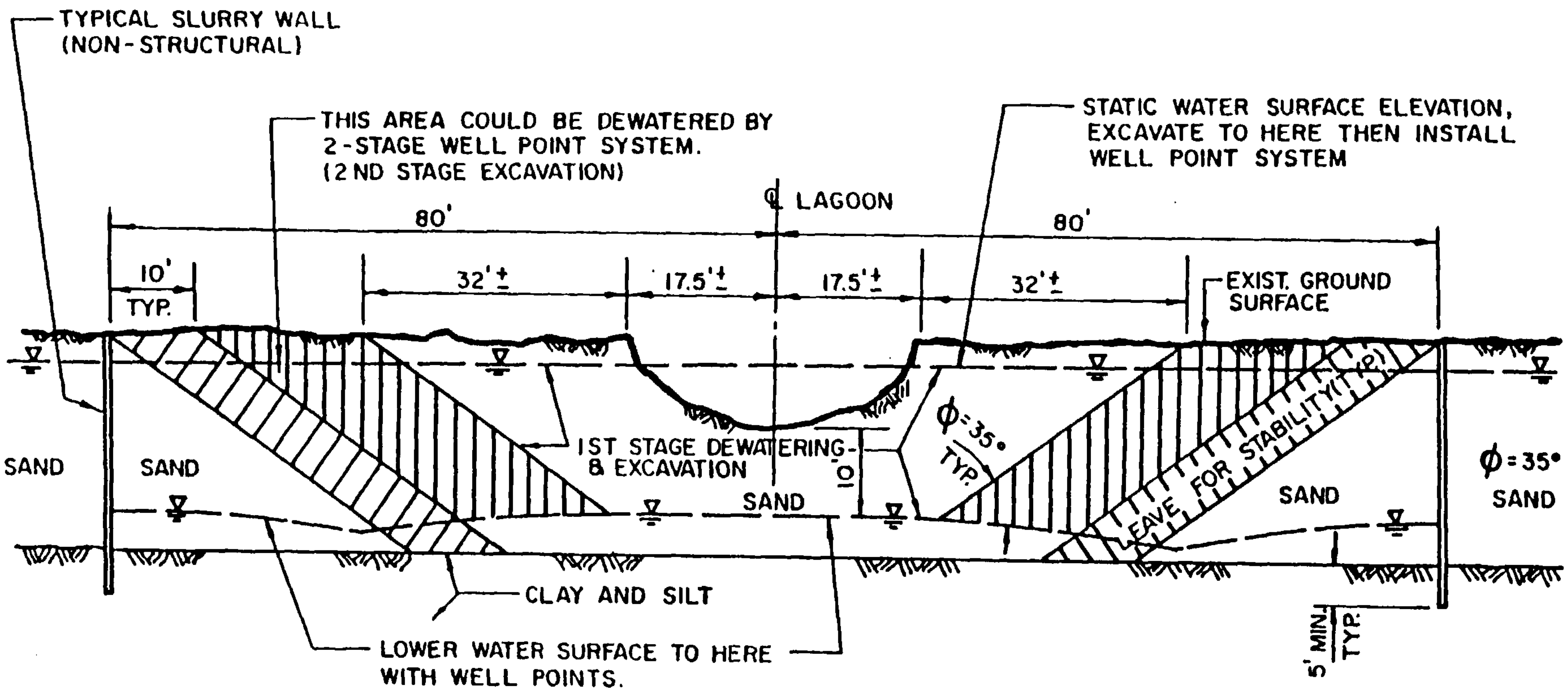
The selection of a cofferdam or a slurry wall enclosure was necessitated by the fact that excavation of the contaminated materials must be done in a dewatered condition so that the limits of contamination can be measured during excavation. To do this, it is necessary to dewater the area inside the cofferdam or slurry wall. When this is done it is mandatory that there be no significant leakage of water through the cofferdam or slurry wall that will significantly lower the water table outside the excavation area. If the water table outside the excavation area is lowered, it could cause settlements of structures which could be very detrimental. Thus, the cofferdam or slurry wall must be deep enough into the "clay" layer, which is about 25 feet below surface, to prevent any significant leakage below the bottom elevation of the cofferdam or slurry wall.

Since either type cutoff wall must be deep enough to penetrate the clay layer and must be completely continuous at its perimeter, it may be necessary to relocate certain structures currently within the proposed excavation area. These are sanitary sewers and storm sewers which can be relocated and perform the same function they are now performing. One other precaution that may be required is the underpinning of the existing water tank, because this type structure is highly susceptible to damage from even slight movements. Mason & Hanger considers the cost of this underpinning to be well worth the risk that would be taken otherwise. After the excavation of the contaminated material is completed, the slurry wall would be cut off just below grade and left in place. Alternatively, part of the cofferdam would also be left in place. Only the parts of the cofferdam that would not cause settlements detrimental to existing structures could be removed.

The foregoing discussion has been limited to the Crescent Ditch. A similar plan could be used for the Oval Lagoon. However, there are no structures close enough to the sides of the lagoon that would limit the width of the area to be excavated. Therefore the slurry wall method may be more economical, especially if the lagoon does not have high concentrations of contamination very deep outside the confines of the present water level. The slurry walls very likely may be placed far enough from the sides of the lagoon that they do not require bracing. There are no samples taken below a depth of 6 feet in the Oval Lagoon. However, one sample at 6 feet had 56,700 ppm PCB, which strongly suggests the contamination extends below that level. The depth of contamination should be determined before or during the excavation to delineate the extent of contamination and minimize removal volume. Figure 15 shows the anticipated arrangement for the slurry wall construction and excavation.

7.3.2 Construction Considerations

There are three existing sanitary sewers in the area of contamination of the Crescent Ditch and the Oval Lagoon. One is a 54 inch sewer running parallel to the railroad track in a general north-south direction. The extreme west end of the Crescent Ditch is over this sewer. Since the west end of this ditch begins at the outfall of a



NOTE: 1. ESTIMATED WEIGHT OF WET SAND IS 120 POUNDS PER SQUARE FOOT.
2. ϕ = ANGLE OF REPOSE.

FIGURE 15: TYPICAL SECTION FOR OVAL LAGOON

NO SCALE

36 inch storm sewer, it is assumed that any PCB contaminations over the 54 inch sewer can be removed without disturbing or rerouting the 54 inch sewer. Further, it is assumed that this excavation will have been done when the bypass has been constructed to eliminate surface water from the 36 inch storm sewer entering the Crescent Ditch. Therefore, the 54 inch sanitary sewer becomes the western-most limit of the practical excavation of deep laden contamination in the Crescent Ditch. In order to remove as much of the contamination as possible, construction of the slurry wall seems to be the most logical method. Once the slurry wall method has been selected for this area, it will probably be best to continue the slurry wall continuously around the Crescent Ditch and effectively isolate the area.

Before the slurry wall can be completed around the Crescent Ditch, it may be necessary to relocate the two active sanitary sewers that cross the ditch. Design of these is straightforward and can be accomplished at any time funds are available. It is possible that if there are any funds left over after construction of the North Ditch by-pass is complete then the sanitary sewers could be relocated at that time.

The only other structure in the way of cleanup of the Crescent Ditch is the railroad spur. It does not need to be relocated until the slurry wall is installed.

There is one sewer that may have to be relocated in the area of the Oval Lagoon.

7.3.2.1 Cleanup of Crescent Ditch

The use of a slurry wall rather than a coffer-dam is preferred in the cleanup of the Crescent Ditch. One reason is that it does not disturb existing structures when it is being installed as does pile driving for a coffer dam. Another reason is that it forms a very good water cutoff. It also allows for maximum excavation of contaminated materials. It is, however, probably more expensive than the coffer dam, especially for excavation of the greatest quantity of material, since the slurry wall must be braced from side to side or otherwise stiffened at the top for lateral stability.

Once additional subsurface investigations reveal the extent of the excavation necessary on each side of the ditch, the exact location of the slurry wall can be determined. When this is done and the slurry wall is installed, dewatering of the area inside the slurry wall can begin. All water within the slurry wall will be treated before disposal. It is suggested that the area of suspected highest contamination be excavated first. This is not necessarily at either end but probably at a location just north of the Die Storage Building in the area of the abandoned outfalls from the main OMC building. Excavation will proceed as required and the material will be hauled away for final disposal.

Since excavation will be done in a dewatered condition, sampling of the material can be performed as excavation proceeds.

An on-site lab can be used to give quick results, within 4 hours, on the contamination levels, thereby minimizing materials to be removed. If it should be determined by actual sampling during excavation that contamination is not as widespread as thought, the amount of materials to be removed can be reduced with a high degree of reliability that the materials remaining are below an acceptable contamination level. When all contaminated materials are removed, the excavated volume will be replaced with clean material to the elevation at or slightly higher than the surrounding area. The area may then be paved and used for other purposes.

7.3.2.2 Cleanup of the Oval Lagoon

The Oval Lagoon is between the crescent-shaped ditch and the E-W portion of the North Ditch. Since there are no structures close to the sides of the lagoon, it may be possible to place the slurry wall back from the sides of the lagoon to where it is possible to excavate at a slope to remove the contaminated materials without bracing between the sides of the slurry wall. It will be necessary to provide some special bracing of the slurry wall at the ends (inlet and outlet) of the lagoon since excavation must be nearer these walls. It is presumed that excavation will not have to be as deep in the lagoon as was required in certain locations in the crescent ditch. The slurry wall will be of the same configuration since no matter how deep the excavation is the slurry wall must cut off all water flow into the area between the walls. Again, excavation will be accomplished under dewatered conditions because the water level will be lowered by pumping. This water will also be treated before discharge if required.

7.3.2.3 Factors Affecting Construction

1. The most important item requiring resolution is how deep and how far from the sides of the Crescent Ditch and Oval Lagoon has the contamination spread. This can be resolved only by additional subsurface investigation. The subsurface investigation will primarily be to determine the depth and concentration of contamination but with little more cost additional analyses can be performed that can reveal data that will be necessary in the design of the slurry wall and the dewatering system.

2. Once the contamination spread has been plotted, it will be necessary to determine how much material must be removed to attain an acceptable level of contamination. This can only be done with consultation and concurrence of EPA. There is a reasonably good possibility that certain areas cannot be economically cleaned up to below 50 ppm, which has been established as the guideline for excavation in soils.

3. It will be necessary for the design engineer to obtain as-built drawings of the sanitary sewers which are proposed to be relocated. Also, it will be necessary to study as-built drawings of the structures

on the south side of the crescent ditch to prepare underpinning or relocation drawings.

4. A study needs to be performed concerning the hydrology of the area and potential effects of heavy rainfalls and/or flooding of area.

7.4 Excavation of Contaminated Soils In and Near the Parking Lot

Contamination has been discovered in the east end of the parking lot adjacent to the North Ditch and the area on both sides of the east access road to the parking lot. Contamination in excess of 10,000 ppm exists at a depth of 9 feet at some locations. Contamination of 150 ppm PCB exists at bore hole number B15 located between the parking lot and North Ditch at a depth of 29 feet below the surface. Approximately 250,000 square feet of parking lot and adjacent material representing a volume of 105,000 cubic yards is believed contaminated to the extent of 50 ppm PCB or greater. There may be 278,000 pounds of PCB in this material (Section 2.3). The above quantities are estimates based on limited core borings.

For the purpose of obtaining an order of magnitude cost estimate, contamination is assumed to extend to a depth of 10 feet or less in the parking lot except near bore hole B15 where contamination extends to a depth of 29 feet. A well point system around the perimeter of contamination is the most practical way of dewatering to a depth of 10 to 15 feet. Below 15 feet, a slurry wall will have to be constructed. The elevation of the parking lot is currently approximately 3 feet above the existing water surface of North Ditch.

The construction of the North Ditch Bypass will be of benefit in this effort, as the North Ditch is a major source of water to recharge the ground water table in the area. The bypass will replace the ditch with a closed pipe, thereby effectively eliminating the ditch as a source of recharge water. Following the drop in the ground water table due to well pointing, then excavation with conventional earthmoving equipment can proceed. It will be necessary to limit the size of the areas around which a well point system is placed. The reason for this would be to prevent a lowering of ground water level over the whole site, which might result in damage to structures located near the dewatered areas, such as the lagoons of the North Shore Sanitary District Plant or buildings on the OMC plant site.

A slurry wall arrangement around the perimeter of deep contamination will be required near bore hole B15 to excavate down to 30 feet. It is assumed for the purpose of estimating costs that the high voltage power line footings need not be disturbed by excavation or slurry wall construction. The location of this power line is shown on the pocket insert map.

A 12 inch high pressure gas line which runs underneath the parking lot will have to be relocated in order to satisfactorily excavate the contaminated material.

7.5 Prevention of Volatilization During Excavation

During the excavation of the contaminated soils and sediments of the North Ditch area, a concerted effort to minimize volatilization of PCBs will be required. Among the measures which are recommended for consideration are the following:

1. Keep the area exposed by excavation as small as possible.

2. Perform the work in as short a time as possible, which will probably mean the use of large equipment to remove the soils and sediments.

3. Perform a preliminary study to compare the various methods available to minimize volatilization. These methods could include covering the exposed soils and sediments with organic materials (such as digested activated sludge, manure, paper mill sludge), covering with synthetic liners, or maintaining a water layer over top of the material, where applicable.

4. Perform the work in the winter, as the rate of volatilization during cold weather is less than during warm weather.

7.6 Alternatives to Excavation

Mason & Hanger has been asked to propose alternatives to excavation of contaminated material which would restrict the movement of PCBs from the area. These alternatives could be temporary measures until funding becomes available to complete the project.

The North Ditch bypass, already proposed as a permanent solution (Phase 1), would prevent washing of PCB sediments into Lake Michigan from this source. The solubilization of PCBs due to contact in the more highly-contaminated areas of the Crescent Ditch would also be eliminated. Then PCB transfer would be limited to groundwater movement and volatilization.

Measurement of ambient PCB concentrations in the air should be taken near contaminated areas and compared against background readings. PCB concentrations in the air near Lake Michigan have been reported (Murphy, T.J. et al, EPA 600/3-78-071, EPA Lab Duluth, Minnesota) to be on the order of 7 nanograms per cubic meter. If PCB concentrations in the air above exposed contaminated soils are significantly higher than background levels, then these areas can be blacktopped or otherwise covered.

The parking lot contamination appears to contribute significantly to groundwater contamination. Dr. Douglas Cherkauer, University of Wisconsin consultant under contract to U.S. EPA to study PCB migration in groundwater at OMC, has not yet completed his study. If groundwater migration is significant, a slurry wall built around the perimter of contamination offers a method of containment.

Costs and environmental implications of slurry wall containment is one of the ultimate disposal options considered by Warzyn Engineering.

Their report is in the appendix. This option (described as Warzyn option number 6) is discussed in Section 9.0. Variations of slurry wall containment and partial excavation and on-site landfill disposal are also discussed in Section 9.0.

Another method of restricting groundwater movement off the site would be to selectively withdraw groundwater from the site and treat it to remove PCBs, if necessary. A study should be made to determine how large the system should be to perform this work, and the associated treatment costs. A better judgement on this system can be made after Cherkauer's report becomes available.

7.7 Cost Estimate

7.7.1 Introduction

There are two distinct phases of the work which are described in this section, and since they can be built at different times, the cost estimate breakdown will indicate the two phases. Phase 1 involves the construction of a bypass around the most highly contaminated portions of the North Ditch and replacement of the E-W portion of the ditch with large storm sewer pipes. The second phase will involve the construction of slurry walls to isolate the areas of high contamination, and following dewatering, the excavation of these soils and sediments.

7.7.2 Unit Prices Used In This Cost Estimate

1. Excavate contaminated material and load into trucks: $13.50 per cy

2. Import clean backfill in place: $10 per cy

3. Remove and relocate railroad track spur: $125 per lf

4. Remove and replace asphalt pavement: $12 per sy

5. Wellpoint and dewater one time: $3 per cy

6. Wellpoint and dewater continuously: $1500 per day

7. Treatment and discharge water: $2000 per day

The costs do not include the following items:

1. Monitoring or on-site lab expenses.

2. Ultimate disposal of contaminated material (See Section 9.0).

3. Cost of permits, easements, inspections, and miscellaneous testing.

7.7.3 Description of Plan for Phase 1 (Bypass)

The following points describe the major items to be included in the proposed plan.

1. Initial mobilization of the contractor to start up the job and to transfer his work crews and equipment onto the site.

2. Excavation of the uncontaminated material for laying of the pipe between the crescent ditch and the E-W portions of the North Ditch.

3. Excavation of contaminated material for laying of the pipe and loading into trucks for transfer to disposal. This material is located in both the western portion of the crescent ditch and E-W part of the North Ditch.

4. Construction of all piping, manholes, drop inlets and outlet structures for the bypass to be operational.

5. Treatment of contaminated wellpoint water with sand filtration and carbon filtration prior to discharge back to the North Ditch.

6. Removal and replacement of that portion of the railroad track spur which must be crossed by the bypass.

7. Removal and replacement of paving in the parking lot and access roads.

8. Construction and removal of bulkheads during excavation of the contaminated materials in the E-W part of the North Ditch.

9. Furnishing and placement of clean fill for those portions where contaminated materials were removed.

10. Operation and pumping of wellpointing system.

11. Construction of a structural slurry wall at the north end of the oval lagoon.

12. Pumping of the surface waters of the North Ditch around the excavation within the E-W portion of the North Ditch.

7.7.3.1 Detailed Cost Breakdown (Phase 1)

Item No.	Description	Cost
1.	Mobilization	$ 50,000
2.	Excavation and replacement of uncontaminated material for pipe laying 3,000 cy @ $4.50/cy	13,500
3.	Excavation of contaminated material and load into trucks ready for transfer and disposal 6,920 cy @ $13.50/cy	93,400
4.	Construct all piping, and appurtenances to make bypass operational	496,000
5.	Treatment of wellpoint water with sand filtration and carbon adsorption	210,000
6.	Removal and replacement of 30 LF of railroad track spur at intersection with bypass	10,000
7.	Remove and replace paving where bypass crosses parking lot and access road, 700 sy @ $12.00/sy	8,400
8.	Relocate 12 inch H.P. Gas Line	25,000
9.	Construct and remove bulkheads during excavation of the contaminated materials in the E-W part of the North Ditch.	35,700
10.	Furnish and place 12,800 cy of clean fill to replace removed contaminated material @ $10/cy	128,000
11.	Operation and pumping of wellpoint system	210,000
12.	Construction of structural slurry wall at the north end of the oval lagoon, 230 L.F. of wall	384,000
13.	Pumping of the surface waters of the North Ditch around the excavation within the E-W portion of the North Ditch	150,000
14.	Emergency bypass pumping	150,000
15.	Contractor supervision	40,000
	Subtotal	$ 2,004,000
	20% Contingency	401,000
	TOTAL (Phase 1)	$ 2,405,000

7.7.4 Description of Plan for Phase 2 (Excavation)

The following points describe the major items to be included in the proposed plan: There are three primary areas which will require excavation of contaminated soils. Two of these, the crescent ditch and the oval lagoon, are being estimated with slurry walls being built to isolate the areas and to control groundwater infiltration. The other area is the east end of the parking lot and the area east of it. Localized lowering of the water table will be performed there to allow for excavation. This estimate will be itemized for the three separate areas.

Crescent Ditch

1. Initial mobilization of the contractor to start up the job and to transfer his work crews and equipment onto the site.

2. Construction of a structural slurry wall completely surrounding the portion of the crescent ditch to be excavated.

3. Relocation of utilities and other miscellaneous items.

4. Dewatering of the area contained within the structural slurry wall.

5. Treating the water with sand filtration and carbon filtration before discharge back to the North Ditch.

6. Underpinning the elevated water tank.

7. Struts and bracing for the structural slurry wall.

8. Excavation of the contaminated soils and loading into trucks for disposal.

9. Purchasing clean fill material and placing it into the excavated portions of the crescent ditch.

10. Measures to mitigate volatilization of the PCBs, including limits on the amount of soils exposed at any time and placement of organic materials left exposed for extended periods of time.

Oval Lagoon

1. Initial mobilization of the contractor to start up the job and to transfer his work crews and equipment onto the site.

2. Construction of a cutoff slurry wall completely surrounding the portion of the oval lagoon to be excavated.

3. Relocation or removal and replacement of utilities and other miscellaneous items, including roads and railroads.

4. Dewatering of the area contained within the non-structural slurry wall by wellpointing.

5. Treating the water obtained from well pointing with sand filtration and carbon filtration before discharge to the North Ditch.

6. Excavation of the contaminated soils and sediments, with loading of them into trucks for haul to final disposal.

7. Purchasing clean fill material and placing it into the excavated portions of the oval lagoon.

8. Measures to mitigate volatilization of the PCBs, including limits on the amount of soils exposed at any time and placement of organic materials on those soils left exposed for extended periods of time.

Parking Lot and Associated Areas

1. Initial mobilization of the contractor to start up the job and to transfer his work crews and equipment onto the site.

2. Relocation or removal and replacement of utilities and other miscellaneous items.

3. Localized dewatering of the area to be excavated by wellpointing.

4. Treating the water with sand filtration and carbon filtration before discharge to the North Ditch.

5. Excavation of the contaminated soils, with loading of them into trucks.

6. Purchasing clean fill material and placing it into the excavated portions of the parking lot.

7. Replacement of the parking lot surface following excavation and backfilling.

8. Measures to mitigate volatilization of the PCBs, including limits on the amount of soils exposed at any time and placement of organic materials on those soils left exposed for extended periods of time.

9. Construction of a slurry wall around bore location B15 to permit dewatering in order to excavate deep contamination.

7.7.4.1 Detailed Cost Breakdown

Crescent Ditch

Item No.	Description	Cost
1.	Mobilization	$ 25,000
2.	Fence removal and relocation 600 LF @ $4.00	2,400
3.	Relocate propane tanks	7,000
4.	Remove and relocate RR track 400 LF x $125	50,000
5.	Reroute 10" San Sewers	17,100
6.	Relocate Water line & hydrant or protect in place.	5,000
7.	Underpin elevated water tank	25,000
8.	Construct slurry wall 31,000 sf. @ $50	1,550,000
9.	Bracing for slurry wall 92 tons @ $1,430	132,000
10.	Demolish slurry wall to below grade	20,000
11.	Dewater 28,900 cy @ $3.00	86,700
12.	Treatment & discharge of water from dewatering	86,700
13.	Excavate contaminated mat'l and load onto trucks 28,900 cy @ $13.50	390,000
14.	Imported clean backfill in place 31,200 cy @ $10	312,000
15.	Measures to mitigate volatilization of PCB	90,000
	Subtotal Crescent Ditch	$ 2,799,100
	20% Contingency	559,800
	TOTAL Crescent Ditch	$ 3,358,900
		(say $ 3,359,000)

Oval Lagoon

Item No.	Description	Cost
1.	Mobilization	$ 25,000
2.	Bit. pavement remove & replace	20,000
3.	New M.H. in 30" Storm Sewer	2,000
4.	Construct non str. slurry wall 600 LF x 30' x $5.18	93,200
5.	Work around power poles	20,000
6.	Wellpoint & dewater 12,500 cy @ $3.00	37,500
7.	Treatment of dewater	37,500
8.	Excavate contaminated mat'l. and load onto trucks 12,500 cy @ $13.50	168,800
9.	Imported clean backfill in place 16,500 cy @ $10.00	165,000
10.	Measures to mitigate volatilization of PCB	117,000
	Subtotal	$ 686,000
	20% Contingency	137,200
	TOTAL Oval Lagoon	$ 823,200
		(say $ 823,000)

Parking Lot

Item No.	Description	Cost
1.	Mobilization	$ 15,000
2.	Reroute 12" HP Gas	75,000
3.	Pavement remove & replace	240,000
4.	Work around 18" storm sewer U.G. elec. 8" U.G. pipe power poles light poles	25,000
5.	Local & continuous wellpoint and dewater $2,000 x 90 days	180,000
6.	Treatment and discharge of dewater	180,000
7.	Excavate contaminated mat'l. and load onto trucks 120,000 cy @ $13.50	1,620,000
8.	Imported clean backfill in place 120,000 cy @ $10.00	1,200,000
9.	Measures to mitigate volatilization of PCB	42,000
10.	Non str. slurry wall for deep excavation 950' x 30' = 28,500 sf. @ $5.18	147,600
11.	Deep excavation of contaminated mat'l. and load onto trucks 400 x 75 x 10 ÷ 27 = 11,111 cy @ $13.50	150,000
	Subtotal Parking Lot	$ 3,874,600
	20% Contingency	774,900
	TOTAL Parking Lot	$ 4,649,500 (say $ 4,650,000)

Cost Summary

Bypass North Ditch	$ 2,405,000
Excavate Crescent Ditch	3,359,000
Excavate Oval Lagoon	823,000
Excavate Parking Lot	4,650,000
OVERALL TOTALS	$11,237,000

7.8 Sequencing of Construction

This section will discuss a schedule for performing the work as outlined previously in the report. Figure 16 is a chart showing a proposed schedule for performing the construction of the bypass around the crescent ditch and oval lagoon portions of the North Ditch and following that, the excavation of the contaminated soils and sediments in those highly contaminated crescent ditch and oval lagoon portions as well as the soils in the parking lot. Each of the two phases should be allotted one full construction season, which should begin generally in late March or early April and continue through good weather, possibly until late October or early November. The bypass should be constructed during the first year and the excavation of the other areas during the second year.

An important consideration for performing this work is the disposal of the contaminated soils and sediments. Prior to the actual construction of the first phase of the work, arrangements must be made for the disposal of the contaminated materials that will be excavated. Temporary disposal in the lagoons being proposed for storing the dredged sediments from the harbor as discussed in Section 8 is one alternative. Lagoon storage would require a delay until the lagoons are constructed. If permanent disposal is to be considered, then arrangements and contractual agreements should be reached with an off-site disposal site or, if disposal on OMC property is agreed to, then the excavation must be coordinated with the construction of the on-site disposal facility.

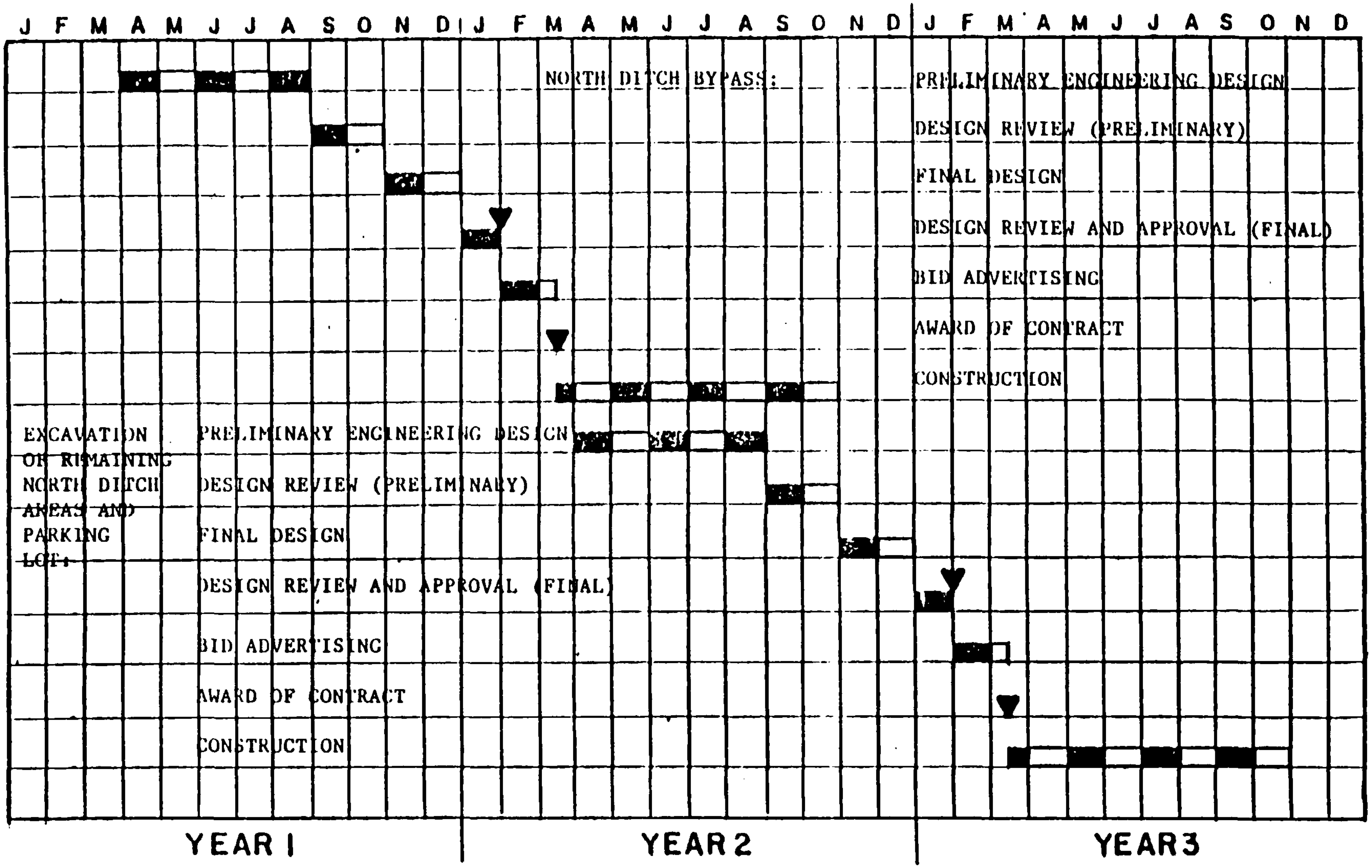


FIGURE 16 :CONSTRUCTION SEQUENCING PLAN
BYPASS AND EXCAVATION FOR NORTH DITCH

8.0 DREDGING, STORAGE AND TREATMENT OF WAUKEGAN HARBOR CONTAMINATED SEDIMENTS

8.1 Introduction

This section will address the dredging, storage and treatment plan for removal of the contaminated sediments located in Waukegan Harbor. The overall program will be discussed in three plans, with each removing a greater portion of the sediments. Plan 1 will remove those sediments containing greater than 500 ppm PCB (dry weight basis). This area is located in Slip #3. Plan 2 will remove sediments containing greater than 50 ppm PCB, which comprises the harbor south to Slip #1. Plan 3 will remove sediments containing greater than 10 ppm PCB, and will include almost all of the harbor, excepting the harbor mouth connecting to Lake Michigan. The plans are discussed separately so that the funding and regulatory agencies can study the options involved in removing the harbor contamination in incremental stages or all at one time.

Costs will be given for each of these plans, so a comparison may be made concerning them, and timetables for completing the work will also be given. Since it is not known when the work will be completed, the costs given will be in December, 1980 dollars.

These plans are contingent upon the use of the vacant Outboard Marine Corporation property located adjacent to the harbor for the temporary storage and treatment facilities. Any alternative relocation of site for storage and treatment would probably result in substantial increases in costs.

The recommended plan for the contaminated sediments in the harbor is:

a. Build a lagoon(s) for a temporary storage facility for the dredged sediments prior to beginning the dredging operation.

b. Dredge the muck sediments and convey them to a lagoon through a pipeline.

c. Dewater the muck sediments in the lagoon and treat the excess water at an on-site treatment plant prior to discharge of this water back to the harbor.

d. Excavate the deep contaminated sand and clay sediments near the old OMC outfall in Slip #3 after dredging the top muck layer. A cofferdam would be built around the contaminated area and water removed before excavation is done.

8.2 Dredging

8.2.1 General Comments

As discussed in Section 6.3, dredging to remove the contaminated sediments is the recommended approach. Because of the very small particle sizes associated with the muck and its semifluid nature, a hydraulic or pneumatic dredge should be used. These dredges are associated with less roiling of the bottom sediments and more complete recovery of the material to be dredged than are bucket or clamshell dredges. Since the material in situ can flow, the preferable technique will be to convey the material with as little water as possible. By doing this, the size of both the lagoons and water treatment system can be decreased.

The cost figures given in this report conform to a dredging system capable of delivering the sediments to the lagoon with a water content of 70 percent and a muck content of 30 percent average. A performance specification should be written for the dredging contractor specifying the maximum average water content of the slurry being pumped to the lagoon. He should be required to demonstrate the capability to meet this standard for muck removal, either by proven prior experience applicable to this project or by a performance test either in Waukegan Harbor or some other location with similar muck-like sediments. Since the dredger will be limited by the size of the lagoon as to the amount of slurry which can be pumped, and completion of the dredging within a suitable time frame being of prime consideration, it will be very important to select a dredger with the proven capability of performing the work.

8.2.2 Dredging of Slip #3

The most contaminated portion of the harbor is Slip #3, thus making the removal of the sediments within its boundaries the most critical. Based on the information now available, it is estimated that all sediments in Slip #3 contain PCB contamination in excess of 500 ppm. The following discussion will describe the proposed program to remove those sediments.

8.2.2.1 Performance Specification for Dredging

A specification detailing the performance expected of the dredger should first be written. This specification should include at least the following considerations:

a. Removal efficiency of the sediments. Since the upper (west) end of Slip #3 is the most highly contaminated, as much as possible of the sediments in the first 300 feet of Slip #3 should be removed. At least a 98% removal efficiency will be the objective. Since the rest of the slip may have structures in place that will impede dredging a removal efficiency of 95% will be the objective.

b. Time of performance. If the dredging operation is performed any time other than winter, then the time for performance of the dredging operation should be as short as feasible to minimize disruption of the Slip #3 operations. Larsen Marine Co. has indicated any time other than winter could seriously affect their operations, but that the least disruptive time while in season would be

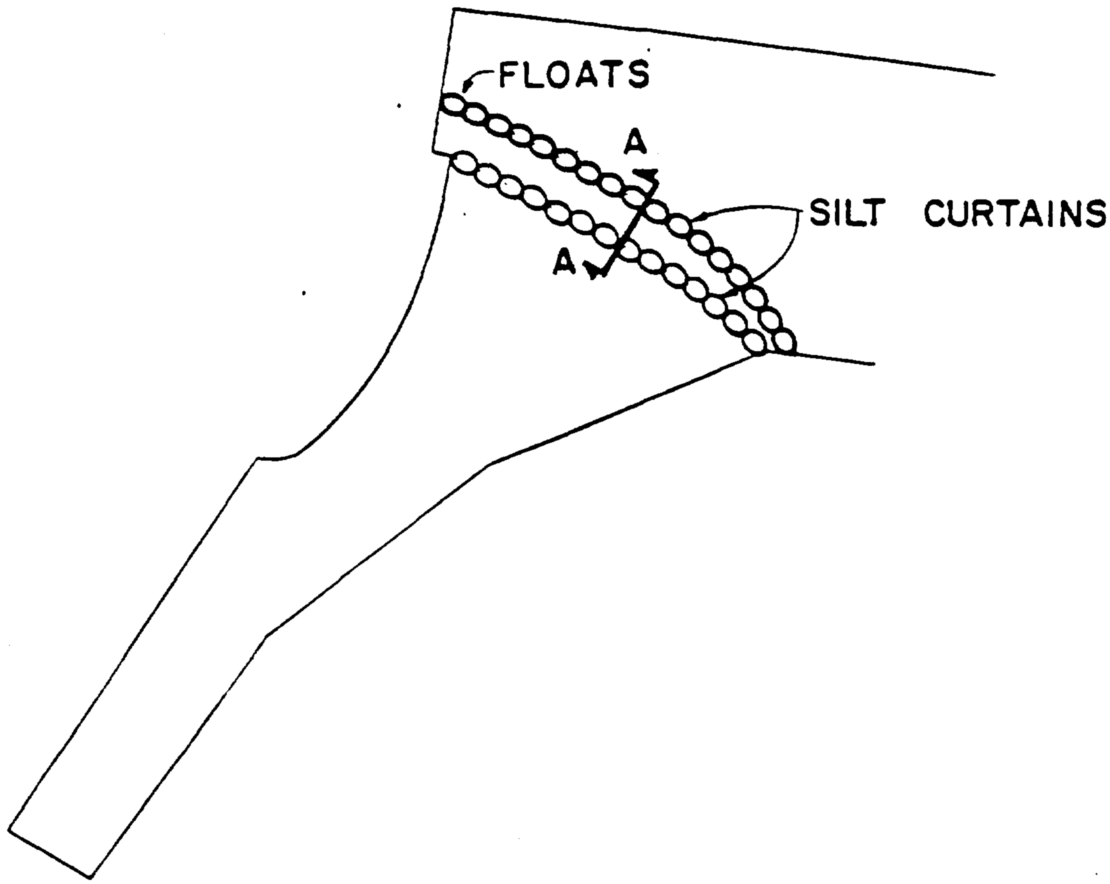
August and September. They normally do not close until late November and open again until early April. Larsen Marine has indicated that they could possibly shorten their season to the second week of November without significant disruption of their operations. Mason & Hanger recommends the dredging operation be required to be completed within two months, and that the dredger be penalized for time required beyond this limit. Time scheduling is discussed further in Section 8.8.

c. Maximum average solids content. The lagoon to which the dredged slurry will be pumped will be constructed to hold a certain volume, with an additional allowance for storage of rainwater, prior to treatment of the excess water. The purpose of the lagoon will be to hold all of the slurry so that for several days or possibly all winter, if dredging is completed late in the year, sedimentation of the solids can occur. Upon completion of the sedimentation, the excess water will be treated prior to discharge back to the harbor. Mason & Hanger recommends that the lagoon be sized to contain the volume of slurry to be removed, plus a free board, plus a contingency factor and an allowance for rain wash. This then allows the water treatment system to be sized only for dewatering. It is then critical that no more than the capacity of the lagoon be pumped. If the total flow exceeded that capacity, then a delay in the dredging would have to occur. The critical time path of this project requires that this not occur, so the dredging specification should give both the estimated quantity of sediments to be dredged and the volume of the lagoon to which they may be pumped. The dredger should be penalized for any quantity in excess of this amount. Mason & Hanger recommends the slurry have an average maximum water content of 70 percent or less.

8.2.2.2 Containment of Roiled Sediments

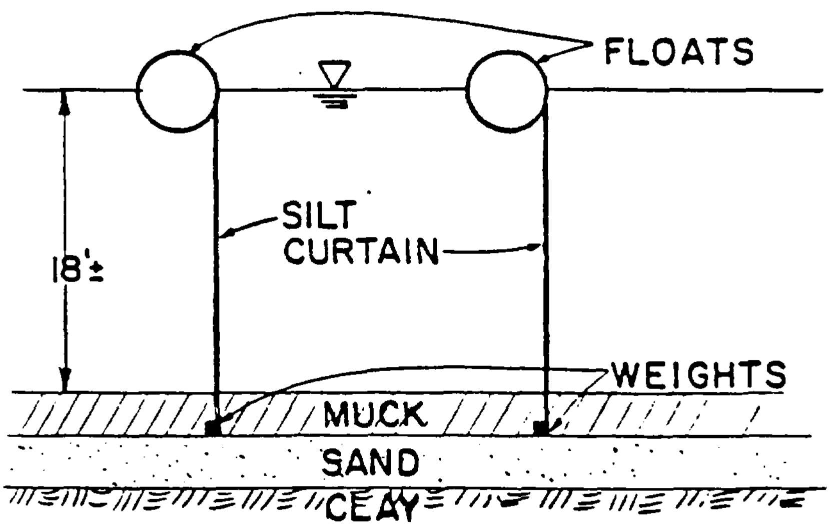
An important factor to be considered in the dredging operation is the containment of the roiled sediments in Slip #3, and not allowing them to contaminate further the other areas of the harbor. Several alternatives are available to perform this function. They would include (1) a dam-like structure across the mouth of the slip, (2) a silt curtain and (3) a steel sheet pile wall. A dam across the mouth would have to be a major structural undertaking, since it would have to be capable of withstanding water elevation changes of up to 4 feet. Bottom sediments would be roiled during dam construction. The disadvantages of building a dam would be the roiling of sediments, expense, and time delays (permits). The steel sheet pile wall would also have several disadvantages. One is that the interlocks are not watertight. For these reasons a dam was not further considered.

The silt curtain alternate would have to be specially engineered to meet the particular design requirements of this application. Mason & Hanger recommends two silt curtains be constructed across the mouth of Slip #3. The tops should be attached to floats and the bottoms should be weighted down to sink into the muck. The second silt curtain will help contain contaminated water and sediments that escape the first silt curtain. Figure 17 shows a possible configuration of the silt curtains.



PLAN OF SILT CURTAINS-SLIP 3 DREDGING

NO SCALE



SECTION A-A

ELEVATION OF DUAL CURTAIN

NO SCALE

FIGURE 17: SILT CURTAIN PLAN & ELEVATION

Provisions should also be made to monitor the level of contamination in the space between the two curtains. If excessive contamination occurs, then measures to control the escape of contaminated sediments should be undertaken. These could include stopping the dreding operation or having an emergency treatment system to treat the water between the two curtains. One possible treatment system could include means to inject flocculents and activated carbon into the water to achieve sedimentation of the sediments. The settled sediments could later be removed by dredging. In addition, the activated carbon would tend to reduce the level of soluble PCB in the water.

8.2.3 Dredging of Harbor Containing Greater Than 50 ppm PCB

The specification for the dredge for this work would contain the same parameters of operation as were discussed in the previous section. However, Mason & Hanger recommends the operation be performed in two separate phases. The first would be the same as discussed in the previous section, and would remove the sediments in Slip #3 prior to dredging the remaining sediments in this portion of the harbor. Silt curtains should be used to contain the operations within Slip #3.

For the second phase of the operation, a single silt curtain would be placed across the harbor near the mouth of Slip #1. It would be very similar to the silt curtains used for Slip #3. If possible, it would be preferable to have this silt curtain in place during the dredging of Slip #3.

The dredge should start dredging at the north end of this portion of the harbor and work his way south. There are two primary reasons for performing the work in this manner. They are (1) the most heavily contaminated material would be removed first and any that is roiled up would have a greater chance of being removed during subsequent dredging and (2) the most heavily contaminated material would be placed on the bottom of the lagoon and would be covered by less contaminated sediments. This would help to minimize the volatilization of PCBs from the lagoon since the least contaminated sediments would be at the top.

Dredging of either portion of the harbor containing greater than 50 ppm PCB or 10 ppm PCB will result in inconvenience to the industries located around the harbor. In particular, Larsen Marine will be adversely affected by any dredging which inhibits or cuts off access to their docks. Coordination of the time period when dredging is performed is a necessity so as to cause the minimum inconvenience to all affected parties.

8.2.4 Dredging of Harbor Containing Greater Than 10 ppm PCB

Again, the specification for this part of the dredging operation would be similar to those presented in the discussion concerning Slip #3. For this portion of the work, however, Mason & Hanger recommends a three phase program. Slip #3 should be dredged as in Plan 1 with silt curtains as previously discussed placed across its mouth. Following the dredging of Slip #3, the harbor containing greater than 50 ppm should be dredged as Plan 2. For Plan 2 operation, a silt curtain should be placed across the harbor north of Slip #1. Plan 3 would comprise the dredging of the remainder of the harbor of the sediments containing greater than 10 ppm PCB. A silt curtain would be deployed in Plan 3. However, because the sediments dredged would be far less contaminated, the silt curtain could be of the more conventional type (as was used in the June 1979 Waukegan Port District dredging). This type of curtain is not anchored into the harbor bottom and is therefore more easily moved along with the dredge as it works its way through the harbor. Final selection of the type of silt curtain to be used will depend upon the turbidity characteristics of the dredge selected. Use of a low turbitity dredge would put less reliance on the silt curtain for containment since less sediment would be resuspended.

Performance of the work in this way would require at least partial closure of the harbor. By proper timing of the operation, the disruption would be minimized.

8.2.5 Special Design Consideration

There are several factors which may complicate the dredging operation. These include the possibility of debris in the sediments, the need for as complete a removal of sediments as possible, the existence of structures presently in the harbor, and the possibility of having to dredge contaminated sand in the upper reaches of Slip #3. All of these have the capability of increasing the average water content of the slurry. This means, of course, that the dredge must be capable of actually delivering to the lagoon a higher solids content that the average previously cited.

The primary effect of debris in the sediments will be to slow down the operation while the suction head of the dredge is being cleaned. This can amount to substantial time periods for certain types of dredges, and this type of dredge should be avoided. One procedure which may be used to accomplish this would be to have a penalty clause in the contract if the dredging were not accomplished within a certain time frame. For certain types of dredges, for example, hydraulic suction pipeline dredges with cutterheads, the head of the dredge makes a pass from right to left through the sediments. Following completion of this pass, it must be raised above the sediments and returned to the starting point for its next pass. This type of dredge can only move its head in one direction when dredging sediments. During the pass above the sediments, only water is being pumped. This may result in a substantial quantity of water being pumped to the lagoon and decreasing the average solids content of the slurry. Some dredges are able to cut in either direction by opening intakes on each end or by moving their shroud to the other side. One possible solution to this problem would be to divert, by using a valve, the flow back to the harbor during the return passes. Another solution, such as shutting down the pump, is also possible, but should not be used for most dredges because their pumps have to be reprimed which requires a substantial amount of time to perform.

With the high degree of contamination in the harbor's sediments, particularly in Slip #3, it is important that as many sediments contaminated with PCBs be removed as is possible. After the majority of the sediments have been dredged, the remaining sediments will likely require more water to remove and convey them, thereby increasing the average water content. This is an important reason for initially selecting a dredge which has a high solids collection rate, requiring less time toward the end of the job for cleaning up any remaining sediments. Mason & Hanger believes that due to the differing levels of contamination, the removal efficiency for different sections of the harbor should also be different. Figure 18 shows the collection efficiencies proposed for the various sections of the harbor. Since the upper 300 feet of Slip #3 contains over 90 percent of the total harbor muck contamination, it is important that greater than 98 percent of these sediments be removed. The remainder of the slip is proposed to have greater than 95 percent of the muck removed. The muck outside Slip #3 is proposed to have a removal efficiency of greater than 90 percent. This would result in approximately 2 percent of the total present pounds of PCB to remain in the harbor. The primary mechanism for verifying the actual removal efficiency would be by depth and PCB measurement of the muck in the various locations following completion of dredging. It is also proposed that following dredging of the harbor, an organic layer of material such as paper mill sludge or a sealant liner be placed over those remaining sediments in Slip #3, particularly the western end, to help mitigate any future spread of contamination.

Presently there are a number of floating and permanent docks located in Slip #3. Due to the high recovery of sediments required and the limited time frame for the dredging, Mason & Hanger recommends complete removal of these docks, including the wood or steel piling which supports them. The only structure which is important enough to not be removed during dredging is Larsen Marine's large boat hoist and associated steel structure. This structure is located away from the most heavily contaminated portion of the slip. If a dredging operation of only Slip #3 is performed in the summer, construction of a new large boat hoisting facility, either on the vacant land owned by OMC adjacent to Larsen Marine or in Slip #1, would help minimize the effects to Larsen Marine caused by completely closing off Slip #3. Following completion of the dredging operation, the docks should be reconstructed.

Contamination is widespread throughout the muck layer in Slip #3. A recent testing program was conducted to determine if the underlying sand and clay was also contaminated near the abandoned OMC outfall which is located in Slip #3. The sand is contaminated in this region, and dredging of the sand or some type of removal means is required. This would probably necessitate a different type of dredge than that required for the muck sediments, further increasing the cost

AREA	PER CENT REMOVAL OF SEDIMENTS
A1, A2, A3	98
A4, A5, A6	95
B1 - B5, C1 - C6	90

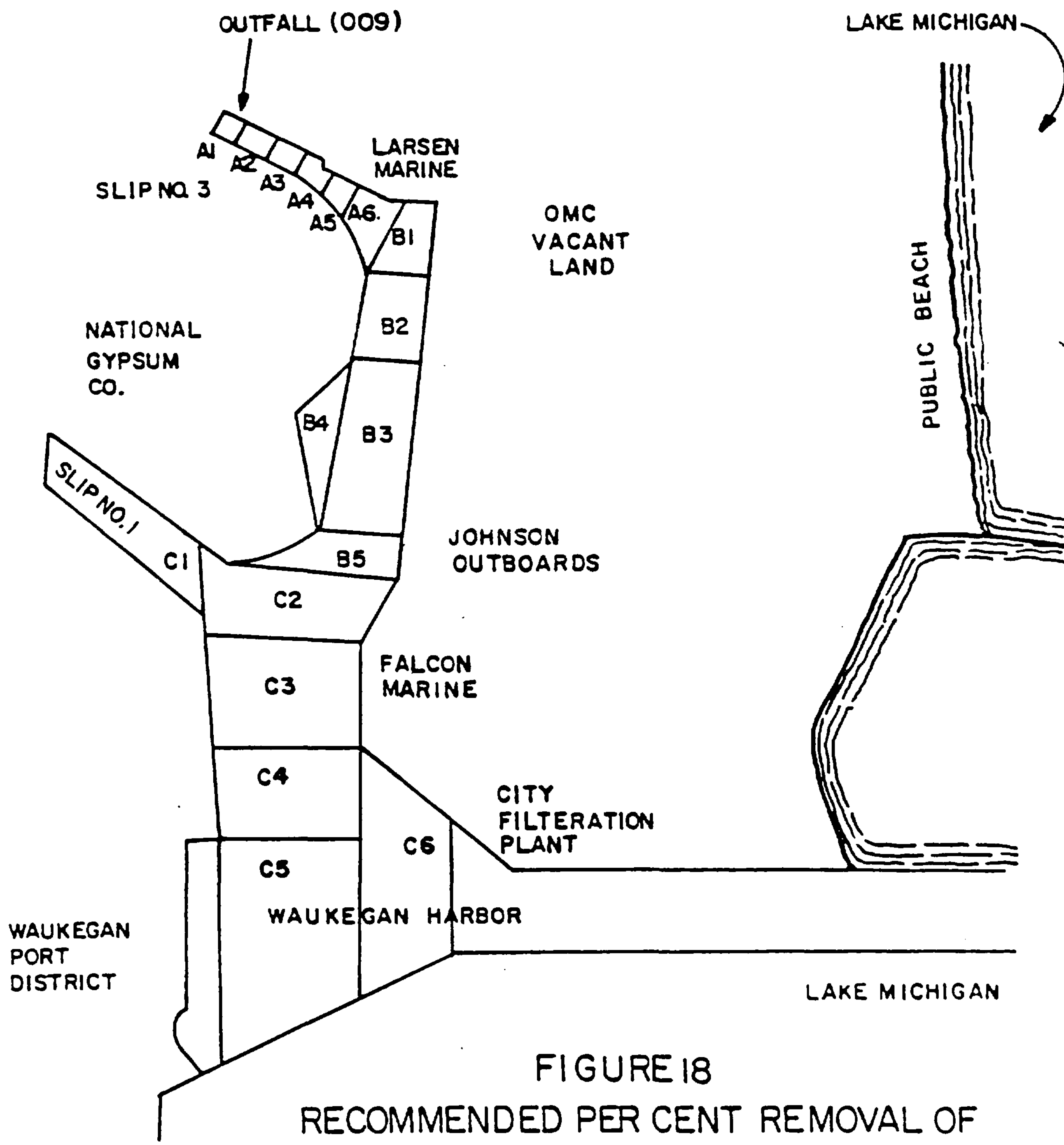


FIGURE 18
RECOMMENDED PER CENT REMOVAL OF MUCK SEDIMENT IN DREDGING OPERATION

of the dredging operation. In general, a larger water content would also be necessary because the heavier weight of sand particles requires a greater velocity to transport them. There is one advantage to dredging the sand and putting it into the lagoon, and that is the greater solids content and dewatering capability of the slurry solids due to the sand being entrained in them. However, the approach recommended for removal of the sand and clay is to construct a cofferdam around the contaminated area and excavate the materials after dewatering. This plan is discussed in Section 8.3.

8.2.6 Conclusions:

1. The best method of dredging the contaminated sediments of the Waukegan Harbor will be by use of a hydraulic or, pneumatic dredges, or a combination of the two methods.

2. The performance specifications should require a minimum average ratio of water to solids content of the slurry being pumped. The specifications should require proven capability of the Contractor's equipment to accomplish the pumping requirements.

3. Slip #3 contains at least 95 percent of the PCB contained in the harbor sediments.

The specifications should make provisions for removal efficiencies in the lower and upper sections of Slip #3 of 95 percent and 98 percent, respectively.

4. Time of performance is critical both to the storage and treatment costs of the PCB laden slurry and the interruption of use of harbor facilities by Larsen Marine. Two months is the recommended maximum time for completion of the dredging of Slip #3 without penalty.

5. A lagoon should be constructed with a volume capacity sufficient to hold the entire quantity of slurry to be pumped from Slip #3 and an additional safety factor. Two lagoons should be constructed for the two larger dredging operations, namely removal to 50 ppm or to 10 ppm. In conjunction with these lagoons will be larger treatment systems to handle the excess water generated during dredging.

6. During the dredging a method of containing the sediments roiled in the water of Slip #3 must be accomplished. The recommended method for accomplishing this is to use two silt curtains.

7. The major difference in the dredging of sediments contaminated greater than 500 ppm vs. greater than 50 ppm or 10 ppm is in the location of the silt curtains and the specified removal efficiency of contaminated sediments required. In either case the dredging should proceed from the closed end of Slip #3 toward open water.

8. Other considerations regarding the dredging are the impact of the piling and other off-shore structures in the harbor.

Large pieces of debris on the bottom or buried in the muck or sand are also potentially disruptive to dredging.

9. The dredging of the muck may require a different type of pump than dredging of the sand. Two different type dredges to remove all the contaminated sediments from the various areas of the harbor may be required if the sand is dredged.

10. The contaminated sand and clay underlying the muck near the old outfall in Slip #3 should be excavated from within a cofferdam which encloses the contaminated area. (Section 8.3)

11. Consideration should be given to storing the less contaminated (less than 50 ppm) sediments in one lagoon and the higher contaminated sediments in the other lagoon. This would allow for separate ultimate disposal options for the different levels of contaminated sediments.

12. OMC must relocate or not use the water intake in Slip #3 while Slip #3 is being dredged.

8.3 Excavation of Deep Contamination in Slip #3

Section 8.2 mentioned possible dredging of contaminated sand in Slip #3. At least one Warzyn boring in Slip #3 away from the outfall show PCB contamination in the top few inches of sand (beneath the muck sediments). Raltech Scientific Services, Inc. has not completed their analyses of all of the borings so it is not known whether the top few inches of the sand is generally contaminated in Slip #3. This sand material would probably be dredged.

In addition to this, there is deep penetration of PCBs into the sand and clay at the OMC outfall as shown by Warzyn's borings B1, B2 and B6. The penetration is too deep to be dredged without spreading PCB contamination. More core borings are needed to define the boundaries of deep penetration.

Based on available information, Mason and Hanger recommend construction of a cofferdam around the perimeter of the deep contamination. The contaminated muck sediments should first be removed by dredging so the cofferdam walls can be constructed on "uncontaminated" material. The cofferdam wall should extend through the sand into clay to avoid water boiling under the structure during excavation. The water inside the cofferdam is then pumped over to the lagoons for water treatment if the water inside the cofferdam exceeds 1 ppb of PCB (or other level set by regulatory agencies). After the water is removed, the contaminated sand and clay is excavated in a dewatered condition. The excavated material can be hauled directly to a landfill disposal site for hazardous waste or placed in the lagoon for later disposal. The cofferdam is then removed and Slip #3 restored to its original function.

The OMC water intake in Slip #3 adjacent to the old outfall should be relocated while this excavation takes place. After Slip #3 is completely decontaminated the water intake can be restored.

A temporary cap should be placed on the exposed contaminated sand after dredging. The cap should minimize solubilization of PCBs into Slip #3 water until excavation can take place. The cap should be an absorbant material which will stay in place on top of the sand.

A possible coffer dam arrangement for an assumed deep contamination configuration is illustrated by Figure 19. The actual cofferdam perimeter can be quite different than that shown depending upon the extent of contamination. A circular arrangement of this type is easier to construct without endangering the shore or nearby buildings and is less costly than a slurry wall arrangement. Sheet piling forms the sides of the cofferdam.

8.4 Temporary Storage of Dredged Sediments

8.4.1 Lagoons

During the dredging operation, the Waukegan Harbor bottom muck sediments will be slurried with water and transferred to a temporary storage lagoon(s). The sediments will be allowed to settle in this lagoon. The excess water will then be withdrawn, treated to remove residual PCBs, and returned to the harbor.

In situ muck sediments in the harbor vary from about 36 to 81 percent solids with the average about 50 percent. During dredging, the muck may be slurried with an average of 70 cubic feet of water to every 30 cubic feet of in situ muck, resulting in an average water content of roughly 85 percent. Some additional water may have to be pumped out of the harbor bottom to insure removal of residual contaminated sediments. Before final disposal, as in a landfill, this excess water must be separated from the sediments.

It is recommended the dredged slurry be stored in large lagoon(s) for this dewatering phase. The most suitable location for these lagoons is the OMC vacant property located adjacent to the harbor. The slurry could be piped directly from the dredge to the lagoon, thereby simplifying the initial transfer. Figure 20 shows a diagram of one possible configuration of the lagoons on this property. Because of the large quantity of sediments potentially requiring dredging, the lagoons should be as large as possible to store them and to simplify the treatment scheme.

The construction of the lagoons should be similar to a secure landfill, with impermeable clay liners and leachate collection systems. One proposed design is shown in Figure 21, which shows a cross-section through the bottom of the lagoon. Above the existing ground should be a one foot clay liner above which lies a leachate collection system. The leachate collection system would have perforated

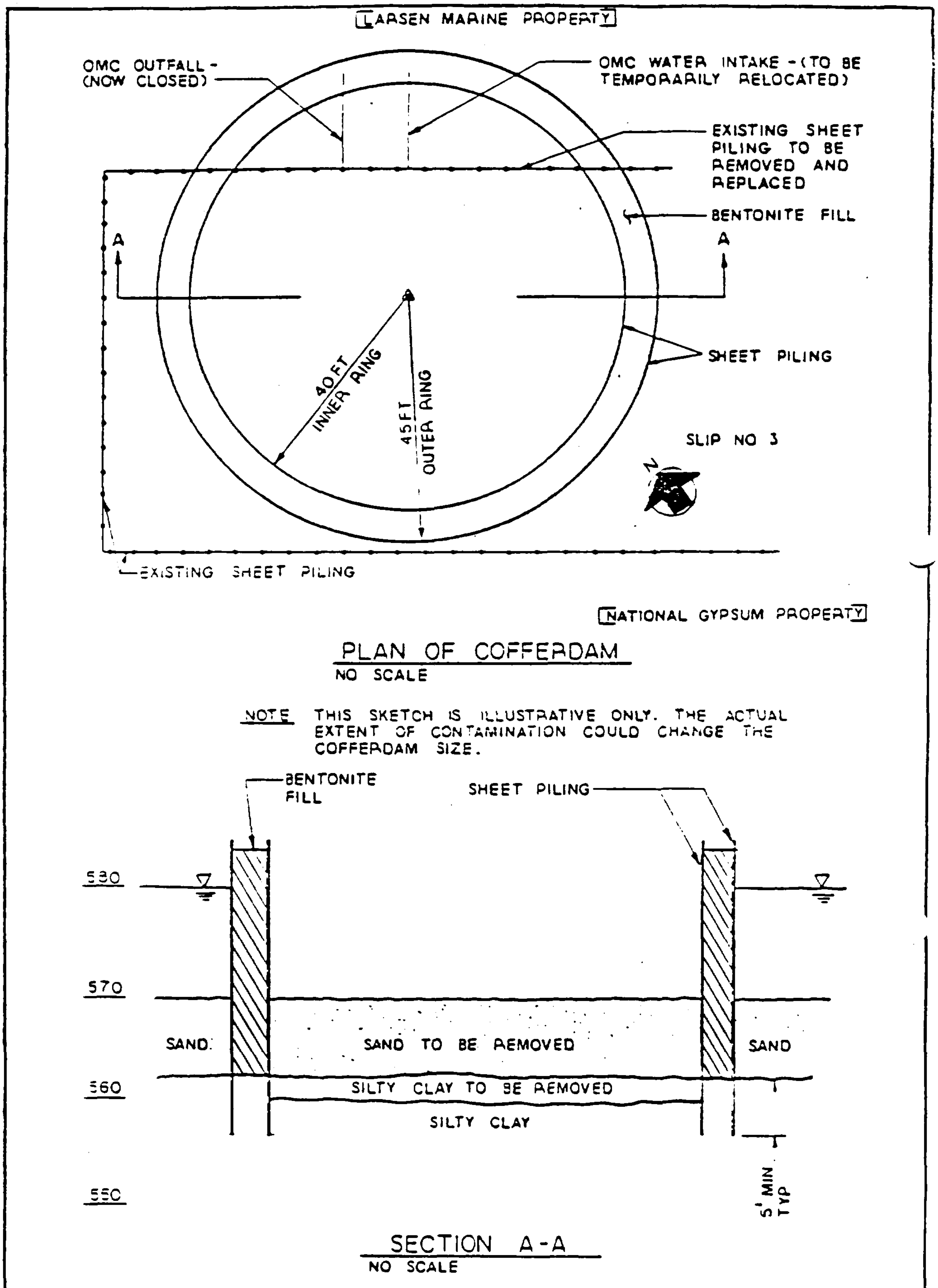


FIGURE 19: COFFERDAM PLAN AND SECTION

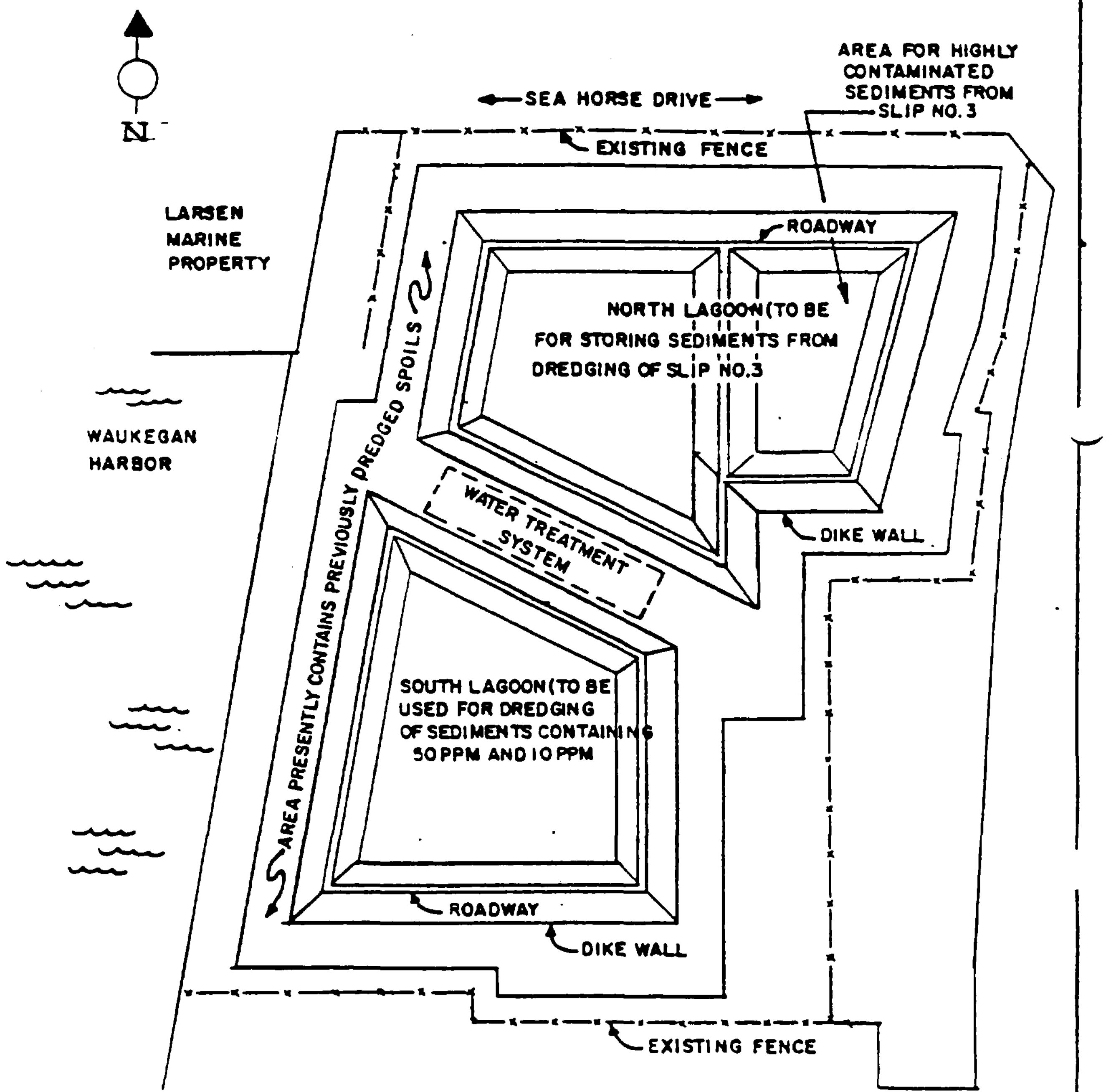
pipes located in an average one foot thick gravel layer. Above this would be 3 feet of impermeable clay which would be compacted during construction to achieve a permeability coefficient of at least 10^{-7} cm/sec.

Mason & Hanger suggests that a six inch thick layer of sand be placed above the clay liner. The purpose of the sand would be to facilitate the dewatering of the sediments in the lagoon. The slightly contaminated sand piles on OMC vacant land might be used for this purpose. A gravity and vacuum-assisted underdrainage system can be used in conjunction with this sand layer to promote the consolidation of the dredged sediments. Prior to consolidation, this material has the consistency of "axle grease", and would prove to be difficult to excavate and handle for final disposal. By using the gravity and vacuum supplemental dewatering system, the moisture content would be further reduced, thereby enhancing the handling characteristics of the sediments. In addition, by continuously removing the excess water from beneath the sediments, the hydraulic head of water available to penetrate the underlying clay layer would be reduced. This would result in less penetration of the clay liner by the leachate and make the system more secure. Another additional benefit from dewatering would be the reduction in volume of the sediments which have to be eventually disposed.

There are several other methods of dewatering dredged sediments in storage lagoons which have proven feasible in other locations but cannot be recommended here due to specific problems associated with dredged material contaminated with a hazardous material. For example, progressive trenching dewatering is a cost effective way of removing excess water from dredged sediments. Since this involves disturbing the surface of the sediments by digging trenches with an amphibious vehicle, it cannot be used for PCB contaminated sediments because of its potential to significantly increase the volatilization of the PCBs. The same would hold true for other surface or crust mixing techniques.

The sides of the lagoons would be dikes. A possible design is shown in Figure 21. The 3 foot clay liner would extend up the slope of the lagoon from its bottom and would be in contact with the contaminated sediments. The dike sides would have a 3:1 slope for stability, and the dike would be constructed of soil material brought in from off the site. The leachate collection system would extend through the dike walls as shown to facilitate the collection of samples and the removal of any leachate collected. Depending upon the quantity of dredged sediments to be stored, the dike walls should be designed to allow for future enlargement of the dike. This would be particularly appropriate if the sediment removal were performed in several different operations spread over an extended time frame.

There is presently a pile of previously dredged material located on the west side of the vacant OMC property owned by Waukegan Excavating Company. The location of this pile is shown in Figure 20. This material is mostly sand which was dredged from near the



OUTBOARD MARINE CORPORATION PLANT NO.1

FIGURE 20

PROPOSED LAYOUT OF LAGOONS ON VACANT OMC PROPERTY

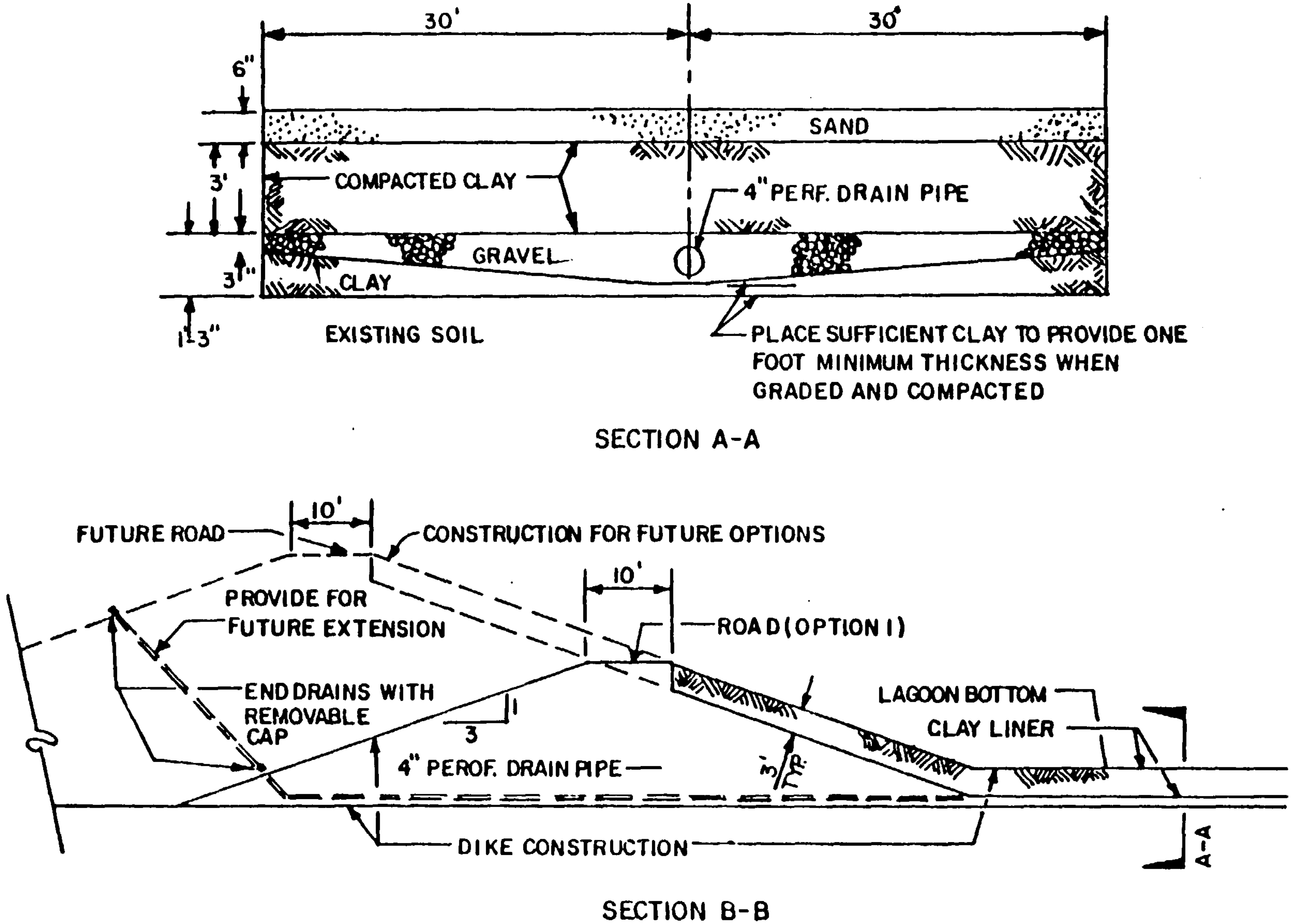


FIGURE: 21 CROSS-SECTIONS OF LAGOON

NO SCALE

mouth of Waukegan Harbor several years ago, and is very slightly contaminated with PCBs. This material might be first used as the sand layer in the lagoon directly underneath the dewatering sediments, and any that is left over be used as fill material for the dikes since it has not been shown to be highly contaminated.

8.4.2 Measures to Minimize PCB Volatilization from Lagoons

During the initial placement of the dredged sediments in the lagoon, a water layer should be kept continuously over them to help minimize volatilization. The reason is PCBs volatilize at a much lower rate from water than from exposed heavily-contaminated sediments. Several procedures during the temporary storage of the sediments are possible for minimization of volatilization. These include (1) placing the less contaminated sediments on top of the more contaminated sediments during dredging, (2) upon completion of dredging, placing a layer of an organic material on top of the dewatering sediments (e.g. digested activated sludge, manure), (3) placing a synthetic liner on top of the water in the lagoon(s) during and following dredging, and (4) segregating the most highly-contaminated material (that from the upper reaches of ip #3) in a separate compartment of one of the lagoons where a more secure cover could be placed.

As discussed previously, the rate of volatilization from the less contaminated sediments would be lower. The organic material would tend to adsorb any PCBs volatilized from the sediments beneath it, thereby preventing or lessening their chances for reaching the air above the lagoon(s). A liner on top of the water would lower the rate of volatilization from any PCBs absorbed in the water. Segregating the most highly contaminated sediments would allow the initiation of the above steps much sooner for these sediments, thereby minimizing their greater potential for emissions. It would also allow separate treatment or disposal options to be performed for these sediments in the future, since it is estimated they will contain a large percentage of the total PCBs in the harbor.

Mason & Hanger recommends a study be performed to .ermine the rates of PCB volatilization from the sediments, soils and waters of the Waukegan site. In addition, this study should examine various methods for lessening these rates by using organic materials and synthetic liners. If possible, the results of this study should be made available during design of the dredging, treatment and storage system. However, if it is not available, the engineer should incorporate the measures discussed above in the design.

8.4.3 Recommendations

1. The temporary storage lagoons should be sized large enough to contain all of the sediments to be dredged plus slurry water. A lagoon sized to contain about 55,000 cubic yards should be large enough to contain 7,300 cubic yards of Slip #3 muck sediments, say 2,000 cubic yards of Slip #3 sand and clay, about 30,000 cubic yards of

slurry water, another 10,000 cubic yards of water used to suck up residual sediments or wash out slurry lines, and another 6,000 cubic yard safety factor. Two lagoons are recommended if the contaminated sediment above 50 ppm or 10 ppm is to be dredged (suggested size 55,000 cubic yards each for 50 ppm and 150,000 cubic yards for 10 ppm); a water treatment system sized to keep up with the dredging is required to avoid excessively large lagoons for these options. If Slip #3 only is dredged, the lagoon should be constructed such that the dike can be built up and capacity increased from 55,000 to 150,000 cubic yards if the rest of the harbor is to be dredged at a later date.

2. The lagoons should be constructed according to Resource Conservation and Recovery Act requirements (Federal Register, May 31, 1979, 40 CFR 761.41) except that groundwater restriction and restriction for location near Lake Michigan will have to be waived.

3. The lagoons should be built on vacant OMC property adjacent to Waukegan Harbor. The lagoons should be built up from the surface using dike and clay liner material hauled in from other sources in order that the lagoon be several feet above ground water. There are also foundations remaining from the previous coke plant located on the site which would interfere with below grade excavation and construction.

4. The most highly contaminated sediments in the upper portions of Slip #3 should be placed in a compartment in one end of one of the lagoons and then be immediately topped with less-contaminated sediments. The material should then be capped with organic rich material (such as digested activated sludge) and perhaps a liner. This action is recommended to prevent excessive volatilization of PCBs.

5. A study is recommended measuring PCB volatilization rates from contaminated sediments and water with and without controls for minimizing volatilization.

6. The lagoon bottom should contain at least 6 inches of sand on top of the clay liner to facilitate dewatering.

7. The lagoon is intended to be a temporary holding site (less than 5 years). The intent is to remove dewatered PCB contaminated spoils and contaminated lagoon material at the end of this period and restore the land to a condition suitable for industrial use.

8.5 Treatment of Excess Water

8.5.1 Excess Slurry Water

Excess water used to slurry harbor sediments into the lagoon(s) plus water used in vacuuming up remaining contaminated harbor sediments and flushing out slurry lines should be treated for PCB removal before being returned to the harbor. Treatment should consist of (1) settling of the sediments in the lagoons, (2) allowing excess water to overflow a weir placed at one end of the lagoon into a smaller sedimentation basin where a polymer is added to coagulate and settle fines, (3) pumping the sedimentation basin water through pressure filters, and (4) conveying the filter effluent through carbon filters to a clear well. The clear well should be monitored for PCB content before returning to the harbor. The U.S. EPA has suggested a 1 ppb (one microgram per liter) limitation on PCB concentration for water returned to the harbor. Figure 22 illustrates the proposed treatment system.

The results of a Mason & Hanger laboratory bench scale study simulating this treatment is presented in the appendix. Conclusions derived from this study are as follows:

1. Several days are required for slurried muck sediments to settle to the point where they occupy the same volume in a lagoon as they did in situ in the harbor.

2. A coagulant material (either 45 ppm of alum, 10 ppm of alum and 5 ppm of certain cationic polymers, or 15 ppm of certain cationic polymers) is required to coagulate and settle colloids left after initial settling of the slurried harbor muck.

3. Sand filtration (3 gpm per square foot) will essentially remove all suspended solids. The filtrate may still contain roughly 70 ppb of soluble PCB.

4. Carbon filtration (12 minute retention time) can remove soluble PCB down to levels less than one part per billion.

The capacity of the treatment system will be dictated by (1) amount of sediments and associated slurry water dredged, (2) size of the lagoons, and (3) availability of treatment equipment. Calgon Corporation, for example, will rent dual media filters with capacities in 200 gpm modules and carbon filters in 500 gpm modules.

If Slip #3 sediments only are dredged, and the lagoon is sized large enough to contain all of the dredged sediments and slurry water, then the water treatment system could be sized relatively small, say at 200 gpm. It would take an estimated 30 days minimum to process approximately 40,000 cubic yards of water which could be the result of dredging Slip #3 sediments.

On the other hand, if more than Slip #3 is dredged, a larger water treatment system is recommended (say 1,500 gpm) to at least partially keep up with the dredging. Otherwise, excessive lagoon sizes would be required. The problem is essentially an economic balance between size of the lagoon, dredging rate, and water treatment plant costs.

Filter backwash water should be returned to the lagoons. Spent filter media and used carbon should be comixed with the contaminated sediments when the dewatering is complete.

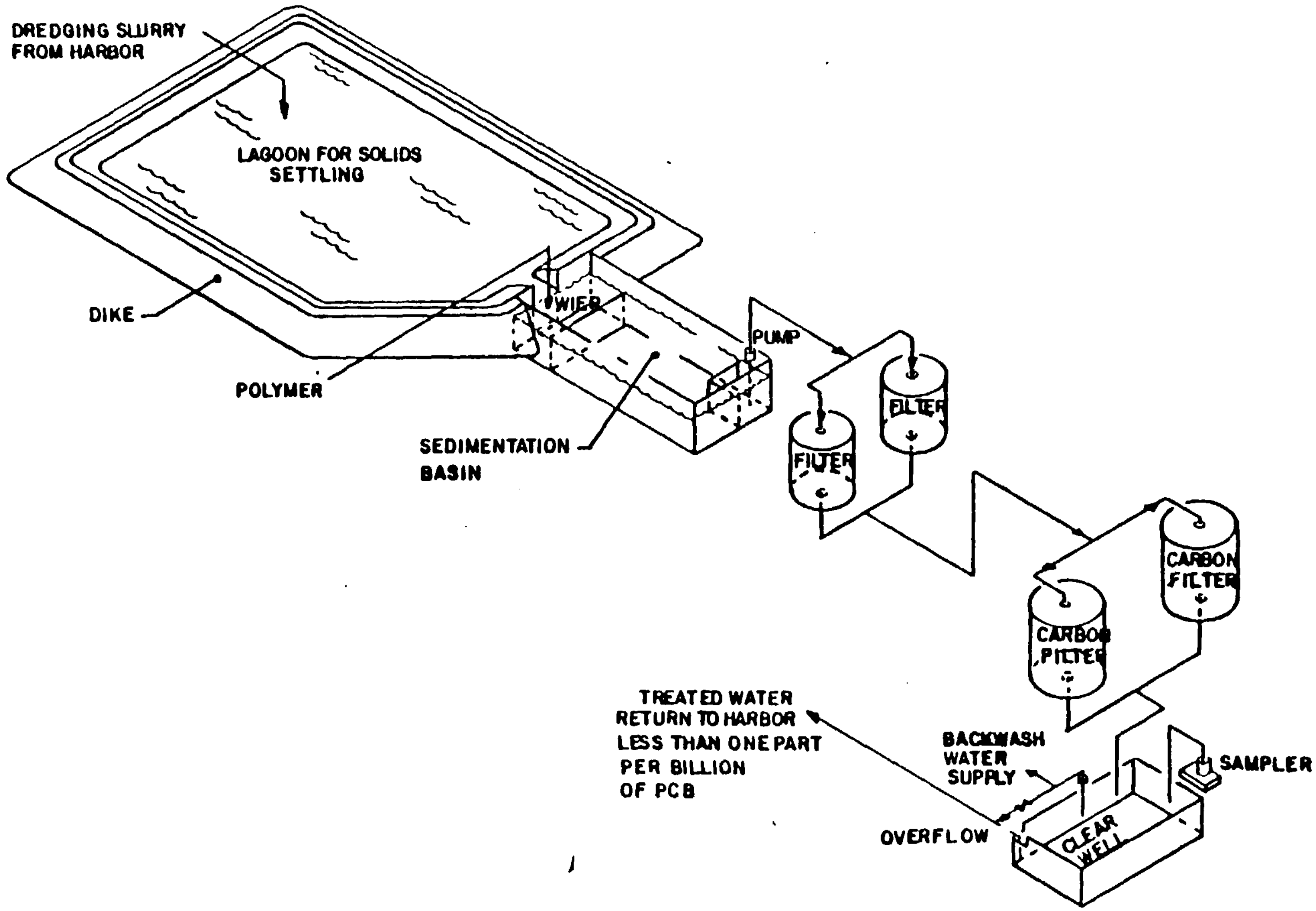


FIGURE 22

PROPOSED TREATMENT SYSTEM FOR EXCESS WATER

The clear well receiving the effluent from the carbon filter is sized to hold a minimum of two hours of flow. During initial shakedown of the system, the flow should be returned to the lagoon until it consistently produces effluent of acceptable quality. Following this, a regular monitoring program should be implemented during treatment plant operation to verify the quality of the effluent.

8.5.2 Rain Water and Leachate Water

After excess slurry water has been treated and the sediments dewatered, rain water and leachate water will still have to be treated. Figure 23 illustrates the proposed leachate and rain water treatment system. The treatment system is essentially the same as the excess slurry water system except that it is operated intermittently, possibly only a few days each month. Also, the system capacity is smaller (say 50 to 200 gpm).

8.6 Discussion of Performing Dredging Operation in Winter

There are several advantages to performing the dredging operation in the winter. These include (1) the least disruption of the normal operation of the harbor, (2) rates of volatilization of PCBs will be lower from contaminated sediments, soils and water, (3) dewatering of the sediments in the lagoons will probably be enhanced by freezing of the overlying and entrained water.

The primary disadvantages include (1) problems with freezing of dredge lines and treatment plant piping, and (2) increased costs of performing work in the winter (especially the dredging and operation of the treatment plant).

It is assumed, for the purposes of this discussion, that the lagoons will be built during the summer, therefore problems associated with earth construction during the winter will be avoided. All of the local industries would prefer the dredging operation be performed in the winter. Falcon Marine has reported performing a hydraulic dredging program during the winter of 1979-80 for the power plant located just to the north of the harbor. This indicated that dredging can be performed during the winter, but special precautions must be taken to ensure that freezing of the harbor water does not unduly impede the dredging operations.

If the dredging program were initiated during the winter, it should be begun in mid-October. This would impact on Larsen Marine's operations, but it is felt to be essential to finish the dredging of Slip #3 prior to very cold weather. It is believed the dredging of Slip #3 can be performed in a period of two months, meaning it should be completed before the very cold weather of January and February arrive. The remainder of the harbor would potentially be completed during the rest of the winter and into spring. If a complete dredging of all of the contaminated sediments could not occur, then the opening of the harbor in the spring would either have to be delayed or the operation continued the next winter.

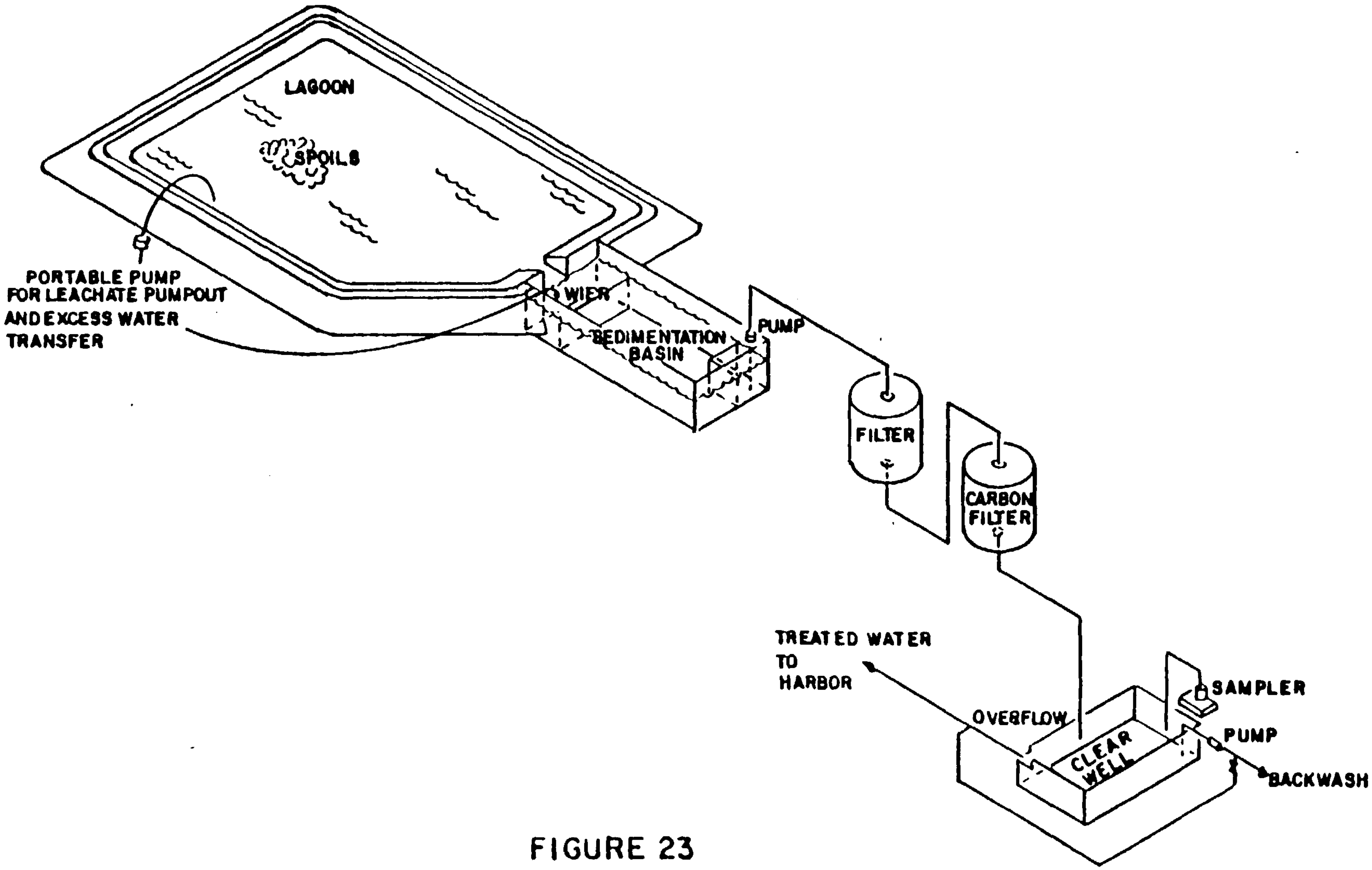


FIGURE 23

PROPOSED RAINWATER AND LEACHATE WATER TREATMENT

If water treatment is to be accomplished during winter, a building would have to be constructed to house sand and carbon filters and pumps to prevent freezing. There would also be problems of freezing in pipelines used to convey slurry. Performing the work during freezing weather would definitely increase operating costs, but may reduce the problems associated with the disruption of industries whose operations depend upon the harbor. However, the water in the lagoons would probably freeze, thereby stopping the dredging of the harbor because no water could be treated. For this reason, it is recommended dredging not be performed in the winter.

8.7 Monitoring Leachate from Lagoons

Groundwater monitoring wells will be installed to satisfy Annex II requirements of regulation 40 CFR part 761.41. At least three well sampling points will be required. The monitoring well discharge should be collected and combined with sediment leachate and rainwater and treated as described in section 8.5.2. The regulation specifies analysis for PCBs, pH, specific conductance, and chlorinated organics (the PCB analysis is all that is required as other chlorinated organic materials are presumed not to be present). The EPA may also require monitoring for terphenyls or their byproducts.

In addition, the lagoon should have a leachate collection system which should be monitored on a predetermined periodic basis and analyzed for PCBs. The leachate collection system consists of perforated pipe in a bed of gravel-sand, which in turn is sandwiched between layers of clay liners. The contents of the perforated pipe is pumped out as required and transferred to a point (e.g. the sedimentation basin) where a uniform sample can be collected for analysis. The leachate water is then treated as in section 8.5.2.

The sediments also rest on a 6 inch bed of sand which will contain perforated pipe. This leachate is also periodically pumped out and disposed as in section 8.5.2. This leachate is removed for the primary purpose of dewatering and consolidating the sediments.

8.8 Cost Estimates for Alternatives

This section includes a discussion of several dredging, temporary storage and excess water treatment schemes to remove the sediments from areas contaminated to three separate PCB concentrating. These levels are (1) greater than 500 ppm PCB in the sediments, (2) greater than 50 ppm PCB in the sediments, and (3) greater than 10 ppm PCB in the sediments. For each of these levels, a particular plan for the removal, storage and treatment of the sediments and associated water will be described. This plan is the initial recommendation for solution of the problem, however, during final design this plan could change substantially due to engineering considerations encountered during design. The cost estimates are suitable, though, for initial projections for the monies required to perform the work.

Priced separately from these three alternatives are cost estimates for removing deep PCB contaminated soils and sediments as described in Section 8.3.

8.8.1 Costs for Removal of Sediments Containing Greater Than 500 ppm PCB (Plan 1)

The estimated costs for removal of sediments containing greater than 500 ppm PCB includes the following items:

1. Dredging 7,300 cubic yards of contaminated muck sediments in Slip #3 and pumping them to a temporary storage lagoon.

2. Construction of a temporary storage lagoon to contain 55,000 cubic yards of slurry, including a special compartment for the most highly contaminated sediments from the west end of Slip #3. (Figure 20).

3. Construction of two silt curtains across the mouth of Slip #3. (Figure 17).

4. Removal of the existing piles and docks located along Larsen Marine's property.

5. Construction of new piles and docks following dredging to replace those removed.

6. Laying a pipeline from the dredging operation to the temporary storage lagoon.

7. Construction of a new large boat hoisting facility near the eastern edge of the northern boundary of the harbor to enable Larsen Marine to continue operations during dredging.

8. Installation of temporary floating docks to replace those lost for service to Larsen Marine within Slip #3.

9. Construction of a building to house the permanent excess water treatment system.

10. Purchasing and installation of a 50 gallon per minute (gpm) treatment system, including pumps, for rainwater and leachate. (Figure 23).

11. Operation and maintenance of the 50 gpm treatment system for a period of two years.

12. Rental of a 200 gpm treatment system for a period of 6 months. (Figure 22).

13. Installation of the 200 gpm treatment system, including connection of the associated piping, control and electrical power.

14. Operation and maintenance of the 200 gpm treatment system, including connection of the associated piping, controls and electrical power.

15. Construction of a clear water storage tank and outfall, including associated piping, for discharging the effluent from the treatment system back to the harbor. (Figure 22).

16. Construction of a reinforced concrete sedimentation basin for receiving the effluent from the temporary storage lagoon. (Figure 22).

17. Installation of a polymer feed system for the waters entering the sedimentation basin. (Figure 22).

18. Construction of roads for access to the treatment system and the storage lagoons. (Figure 20).

19. Providing electrical service for the treatment systems.

20. Construction of new fence for the existing unfenced sections surrounding the temporary storage site. (Figure 20).

21. Special measures for controlling volatilization, including the placement of a layer of adsorbent material on top of the sediments and a synthetic membrane liner on top of the water during dewatering. There will be a thicker layer of adsorbent material placed on top of the most highly contaminated sediments.

22. Construction of a monitoring well system, consisting of 6 wells.

23. Grading of the site prior to construction of the temporary storage lagoons.

24. Analysis costs for the effluent water and monitoring well water.

25. Operating expenses, including chemicals and electricity.

26. Mobilization.

27. Engineering, land acquisition, permitting costs, final excavation, disposal and restoration of site are <u>not included</u> in the costs.

28-34. Excavation of deep contamination in Slip #3.

Detailed Cost Breakdown for Items 1 thru 26 (Plan 1)

Item No.	Description	Cost
1.	Dredging (7,300 cy muck @ $16/cy)	$ 117,000
2.	Construct 55,000 cy Capacity Lagoon	708,000
3.	Silt Curtains 2 @ $85,000 each	170,000
4.	Remove Docks	20,000
5.	New Docks	52,000
6.	Temporary Pipe	13,000
7.	Boat Facility - Hoist	14,000
8.	Temporary Floating Docks	10,000
9.	Building, 1500 sf	75,000
10.	Purchase and Install 50 gpm Treatment System	52,000
11.	Operating Costs, 50 gpm Treatment System - 2 years	136,000
12.	Rental, 200 gpm Treatment System - 6 months	150,000
13.	Install 200 gpm Treatment System	13,000
14.	Operation & Maintenance, 200 gpm Treatment System - 6 months	15,000
15.	Outfall & Storage Tank	25,000
16.	Sedimentation Basin	60,000
17.	Polymer Feed System	5,000
18.	Access Roads	34,000
19.	Electrical Service	30,000
20.	New Fence	15,000
21.	160,000 sf Polyethylene & Sludge to control volatilization	31,000
22.	Monitoring Wells	3,000
23.	Site Grading	100,000
24.	Analysis Cost	30,000
25.	Operating Expenses	8,000
26.	Mobilization	30,000
	Subtotal	$1,916,000
	Contingency (20%)	383,000
	TOTAL (Plan 1 items 1 thru 26)	$2,299,000

Detailed Cost Breakdown for Deep Contamination in Slip #3

The following cost is based on construction of a cofferdam with an inner ring diameter of 80 feet and an outer ring diameter of 90 feet.

Item No.	Description	Cost
28.	Temporary Cap on Sand to Control Solubilization of PCB	$ 5,000
29.	Cofferdam construction & Removal	227,000
	Drive & Pull Sheets 13353 S.F. @ $10/S.F. = $133,530	
	Walers for inner & outer = 60,000	
	Excavate sand between rings 346 cy @ $10/cy = 3,460	
	Bentonite Grout 1,000 cy @ $20/cy = 20,000	
	Removal of Grout = 10,000	
30.	Excavation of Contaminated Sand & Clay	24,000
	Excavate sand 1117 cy @ $10/cy = $11,170	
	Excavate clay 394 cy @ $25/cy = $ 9,850	
	Hauling & Unloading Sand & Clay = 2,980	
31.	Dewater cofferdam, estimate job cost	20,000
32.	Restore Sheet Pile & Fill	37,000
	Furnish and Drive permanent sheet piling 2240 S.F. @ $12/S.F. = $26,880	
	Refill w/sand 950 cy @ $10/cy = $ 9,500	
33.	Contractor Overhead Items 27 thru 31	46,000
34.	Water Treatment and Monitoring	30,000
	Subtotal Items 28 thru 34	$ 389,000
	Contingency (20%)	78,000
	TOTAL Deep Contamination Removal	$ 467,000

8.8.2 Costs for Removal of Sediments Containing Greater Than 50 ppm PCB (Plan 2)

The estimated costs for removal of sediments containing greater than 50 ppm PCB include the following items:

1. Dredging 45,000 cubic yards of contaminated muck sediments in Slip #3 and Waukegan Harbor north of Slip #1 and pumping them to a temporary storage lagoon.

2. Construction of two temporary storage lagoons to each contain 55,000 cubic yards of slurry, including a special compartment in the north lagoon for the most highly contaminated sediments from the west end of Slip #3. (Figure 20).

3. Construction of two silt curtains across the mouth of Slip #3 (Figure 17) and a single silt curtain across the harbor just north of Slip #1.

4. Removal of the existing piles and docks located along Larsen Marine's property.

5. Construction of new piles and docks following dredging to replace those removed.

6. Laying a pipeline from the dredging operation to the temporary storage lagoon.

7. Construction of a new large boat hoisting facility near the eastern edge of the northern boundary of the harbor to enable Larsen Marine to continue operations during dredging.

8. Installation of temporary floating docks in the main harbor to replace those lost for service to Larsen Marine within Slip #3.

9. Construction of a building to house the permanent excess water treatment system.

10. Purchasing and installation of a 200 gallon per minute (gpm) treatment system, including pumps, for rainwater and leachate. (Figure 23).

11. Operation and maintenance of the 200 gpm treatment system for a period of two years.

12. Rental of a 1,500 gpm treatment system for a period of 6 months. (Figure 22).

13. Installation of the 1,500 gpm treatment system, including connection of the associated piping, controls and electrical power.

14. Operation and maintenance of the 1,500 gpm treatment system, including connection of the associated piping, controls and electrical power.

15. Construction of a clear water storage tank and outfall, including associated piping, for discharging the effluent from the treatment system back to the harbor. (Figure 22).

16. Construction of a reinforced concrete sedimentation basin for receiving the effluent from the temporary storage lagoon. (Figure 22).

17. Installation of a polymer feed system for the waters entering the sedimentation basin. (Figure 22).

18. Construction of roads for access to the treatment system and the storage lagoons. (Figure 20).

19. Providing electrical service for the treatment systems.

20. Construction of new fence for the existing unfenced sections surrounding the temporary storage site. (Figure 20).

21. Special measures for controlling volatilization, including the placement of a layer of adsorbent material on top of the sediments and a synthetic membrane liner on top of the water during dewatering. There will be a thicker layer of adsorbent material placed on top of the most highly contaminated sediments.

22. Construction of a monitoring well system, consisting of 9 wells.

23. Grading of the site prior to construction of the temporary storage lagoons.

24. Analysis costs for the effluent water and monitoring well water.

25. Operating expenses, including chemicals and electricity.

26. Mobilization

27. Engineering, land acquisition, permitting costs, final excavation, disposal and restoration of site are not included in the costs.

28-34. Excavation of deep contamination in Slip #3 (same as for Plan 1).

Detailed Cost Breakdown for Items 1 thru 26 (Plan 2)

Item No.	Description	Cost
1.	Dredging (45,000 cy muck @ $9/cy)	$ 405,000
2.	55,000 cy Capacity Lagoons (2)	1,441,000
3.	Silt Curtains (3) @ $85,000 ea.	255,000
4.	Remove Docks	20,000
5.	New Docks	52,000
6.	Lay Temporary Pipe Line	35,000
7.	Boat Hoist Facility	14,000
8.	Temporary Floating Docks	10,000
9.	Building, 1500 sf	75,000
10.	Purchase & Install 200 gpm Treatment System, Incl. Pumps	110,000
11.	Operation Costs of 200 gpm Treatment Systems - 2 years	142,000
12.	Rental of 1500 gpm Treatment System - 6 months	682,000
13.	Install 1500 gpm Treatment System	20,000
14.	Operation & Maintenance of 1500 gpm System - 6 months	20,000
15.	Outfall & Storage Tank - 180,000 Gallon Capacity	52,000
16.	Construction of Sedimentation Basin	112,000
17.	Installation of Polymer Feed System	5,000
18.	Construction of Access Roads	64,000
19.	Electrical Service	40,000
20.	New Fence	30,000
21.	Polyethylene & Sludge to control volatilization	62,000
22.	Monitoring Wells (9)	5,000
23.	Site Grading	100,000
24.	Analysis Cost	40,000
25.	Operating Expenses (Incl. Chem. & Elec.)	12,000
26.	Mobilization	40,000
	Subtotal	$3,843,000
	Contingency (20%)	769,000
	TOTAL (Plan 2 items 1 thru 26)	$4,612,000

The costs for removing the deep contamination in Slip #3 are the same as listed in Section 8.8.1.

8.8.3 Costs for Removal of Sediments Containing Greater Than 10 ppm PCB (Plan 3)

The estimated costs for removal of sediments containing greater than 10 ppm PCB include the following items:

1. Dredging 166,000 cubic yards of contaminated muck sediments in Slip #3 and pumping them to temporary storage lagoons.

2. Construction of two temporary storage lagoons to contain 150,000 cubic yards of slurry each, including a special compartment for the most highly contaminated sediments from the west end of Slip #3. (Figure 20).

3. Construction of two silt curtains across the mouth of Slip #3 (Figure 17) and a single silt curtain across the harbor just north of Slip #1.

4. Removal of the existing piles and docks located along Larsen Marine's property.

5. Construction of new piles and docks following dredging to replace those removed.

6. Laying a pipeline from the dredging operation to the temporary storage lagoon.

7. Construction of a new large boat hoisting facility near the eastern edge of the northern boundary of the harbor to enable Larsen Marine to continue operations during dredging.

8. Installation of temporary floating docks to replace those lost for service to Larsen Marine within Slip #3.

9. Construction of a building to house the permanent excess water treatment system.

10. Purchasing and installation of a 200 gallon per minute (gpm) treatment system, including pumps, for rainwater and leachate. (Figure 23).

11. Operation and maintenance of the 200 gpm treatment system for a period of two years.

12. Rental of a 1,500 gpm treatment system for a period of 6 months. (Figure 22).

13. Installation of the 1,500 gpm treatment system, including connection of the associated piping, control and electrical power.

14. Operation and maintenance of the 1,500 gpm treatment system, including connection of the associated piping, controls and electrical power.

15. Construction of a clear water storage tank and outfall, including associated piping, for discharging the effluent from the treatment system back to the harbor. (Figure 22).

16. Construction of a reinforced concrete sedimentation basin for receiving the effluent from the temporary storage lagoon. (Figure 22).

17. Installation of a polymer feed system for the waters entering the sedimentation basin. (Figure 22).

18. Construction of roads for access to the treatment system and the storage lagoons. (Figure 20).

19. Providing electrical service for the treatment systems.

20. Construction of new fence for the existing unfenced sections surrounding the temporary storage site. (Figure 20).

21. Special measures for controlling volatilization, including the placement of a layer of adsorbent material on top of the sediments and a synthetic membrane liner on top of the water during dewatering. There will be a thicker layer of adsorbent material placed on top of the most highly contaminated sediments.

22. Construction of a monitoring well system, consisting of 9 wells.

23. Grading of the site prior to construction of the temporary storage lagoons.

24. Analysis costs for the effluent water and monitoring well water.

25. Operating expenses, including chemicals and electricity.

26. Mobilization

27. Engineering, land acquisition, permitting costs, final excavation, disposal and restoration of site are not included in the costs.

28-34. Excavation of deep contamination in Slip #3 (same as for Plan 1).

Detailed Cost Breakdown for Items 1 thru 26 (Plan 3)

Item No.	Description	Cost
1.	Dredging 166,000 cy muck @ $7/cy	$1,162,000
2.	Construction of two 150,000 cy Capacity Lagoons	3,277,000
3.	Silt Curtains (3)	255,000
4.	Remove Docks & Piles	20,000
5.	New Docks & Piles	52,000
6.	Temporary Pipe Line	40,000
7.	Construction of Boat Hoist Facility	14,000
8.	Temporary Floating Docks	10,000
9.	Building, 1500 S.F.	75,000
10.	Purchase & Install 200 gpm Treatment, Including Pumps	110,000
11.	Operating Costs of 200 gpm Treatment System for 2 years	142,000
12.	Rental of 1500 gpm Treatment - 8 months	784,000
13.	Install 1500 gpm Treatment System	20,000
14.	Operation & Maintenance of 1500 gpm Treatment System 8 months	40,000
15.	Outfall & Storage Tank	52,000
16.	Construction of Sedimentation Basin	112,000
17.	Installation of Polymer Feed System	5,000
18.	Access Roads	70,000
19.	Electrical Service	40,000
20.	New Fence	30,000
21.	Polyethylene & Sludge to Control Volatilization	80,000
22.	Monitoring Wells	5,000
23.	Site Grading	100,000
24.	Analysis Costs	60,000
25.	Operating Expenses (Incl. Chem. & Elec.)	24,000
26.	Mobilization	40,000
	Subtotal	$6,619,000
	Contingency (20%)	1,324,000
	TOTAL (Plan 3 items 1 thru 26)	$7,943,000

The cost for removing the deep contamination in Slip #3 are the same as listed in Section 8.8.1.

8.9 Cost Estimate for Restoration of OMC Vacant Land

The costs developed here include an estimated $5 per cubic yard for placement of the dewatered lagoon solids in trucks and regrading the site after the contaminated material has been removed. Cost for transportation to a final disposal site, placement in the site, etc., are discussed in Section 9.0.

Plan 1 assumes 7,300 cubic yards of muck, 2,000 cubic yards of sand and clay from Slip #3, and possibly 8,000 cubic yards of extraneous material. Plan 2 assumes 47,000 cubic yards of sediments and possibly 15,000 cubic yards of extraneous material. Plan 3 assumes 168,000 cubic yards of sediments plus possibly 20,000 cubic yards of extraneous material.

	Plan 1	Plan 2	Plan 3
Level of Removal of PCB	Over 500 ppm	Over 50 ppm	Over 10 ppm
Loading onto Trucks	$ 87,000	$310,000	$ 940,000
Final Regrading of Site	125,000	325,000	400,000
Subtotal	$212,000	$635,000	$1,340,000
20% Contingency	43,000	127,000	268,000
Total	$255,000	$762,000	$1,608,000

8.10 Sequencing of Construction

8.10.1 Introduction

This section will discuss potential schedules for performing the work associated with removal of PCB contamination in Waukegan Harbor. A proposed schedule for each of the three degrees of contamination to be removed will be discussed individually. The schedule will outline one proposed method for performing the work to indicate the associated relative time frame. Of course, the schedule may vary depending upon the circumstances prevailing at the time the engineering plans and specifications are prepared and the contract is let.

8.10.2 Plan for Greater than 500 ppm PCB

This plan includes the removal of the contaminated sand and sediments in Slip #3. Included in the plan is the building of a lagoon on the vacant OMC property, constructing and/or renting the treatment system, and dredging the muck and excavating some sand and clay in the slip. Mason & Hanger estimates the construction of the lagoons will require four months following award of a construction contract, the purchasing and installation of the treatment system will require five months, the dredging operation will require two months, and construction of a cofferdam and excavation of the sand and clay will require two and one half months. The stated times are optimum and could vary dependent upon unforeseen conditions that may arise when construction is actually undertaken.

The optimum time for the construction of the lagoon is in the warm weather months from May to October. The treatment system could also most easily be constructed from May to October, but the timing is not as critical. The sedimentation basin and final effluent holding tank should be constructed in conjunction with the lagoon, and a building to house the treatment system would also be best constructed during this time. However, after the building is constructed, the treatment equipment can be installed in the winter. Since it is anticipated the treatment equipment may be leased, then it would be preferable to bring in the equipment when treatment of the excess water is actually required. The cofferdam could be constructed in the winter following dredging of Slip.#3

A chart showing the proposed scheduling of construction for dredging of Slip #3 is shown in Figure 24. It is estimated that 4.5 months would be required for design and awarding of a contract for the construction of the lagoon and treatment system. This presupposes there are no undue delays for approval of the design and in receiving permits from all affected parties. If this work were begun at the start of a year, the construction of the lagoon could begin by mid-May. The construction of the lagoon should be completed within 4.5 months, thereby allowing the dredging to begin in mid-October. Approximately two months should be required to complete the dredging operation, including the removal of the piers in the slip and installation of the silt curtains.

While the dredged water is contained in the lagoon over the winter for dewatering purposes, the cofferdam can be constructed to accomplish removal of the contaminated sand and clay near the previous OMC outfall. Since very little water will be removed during this operation, the water should be conveyed to the lagoon and the piping should be heat traced to prevent freezing. This operation should be completed within 2.5 months.

Sometime during the early part of the next year, the treatment equipment can be installed. Operation can begin after the water in the lagoon thaws, probably in late March or early April. It is anticipated the treatment of the excess water can be completed within two months. Following this, a small treatment system will be required to treat the leachate and rainwater from the lagoon until final disposal of the dewatered sediments occurs.

8.10.3 Plan for Greater than 50 ppm PCB

This plan would contain the same elements as the plan for greater than 500 ppm PCB as outlined in Section 8.10.2, except two lagoons would have to be constructed, a larger treatment system would be required, and a greater quantity of muck would be removed by dredging. Mason & Hanger anticipated the dredging of Slip #3 would proceed as outlined in Section 8.10.2. The slurry would be pumped to one of the lagoons which would have to be completed in time to receive it. However, the other lagoon could continue being constructed while dredging of Slip #3 was proceeding. It would be preferable to have both lagoons completed prior to initiating the dredging operation in Slip #3.

Early the next year, when freezing is no longer a problem (probably in early April), dredging of the remainder of the harbor containing between 50 and 500 ppm PCB could proceed. It is anticipated this operation would last approximately 3 months, and would effectively shut down Larsen Marine and all of the harbor north of Slip #1 during this period of time. Water treatment would proceed during this operation, as the excess water from one lagoon would be treated while the other lagoon was being filled. The treatment of the excess water is projected to last 2 months following completion of the dredging. Again, a small permanent treatment system would be required for the rainwater and leachate generated at the lagoons. Figure 25 shows the proposed schedule.

8.10.4 Plan for Greater than 10 ppm PCB

This plan would contain the same components as the plan for greater than 50 ppm PCB as outlined in Section 8.10.3. The exceptions would include: (1) larger lagoons, which would possibly necessitate longer construction times, and (2) more material to dredge, which would necessitate either a longer dredging time or the use of multiple dredges.

The schedule (Figure 26) only changes in the time period required for dredging (6 months instead of 3 months), and an 8 month time period for the water treatment, much of it coinciding with the dredging. The reason for this is the lagoons cannot economically be built large enough to contain all of the dredged slurry, thereby necessitating the water treatment system be large enough to keep pace with the dredging operation.

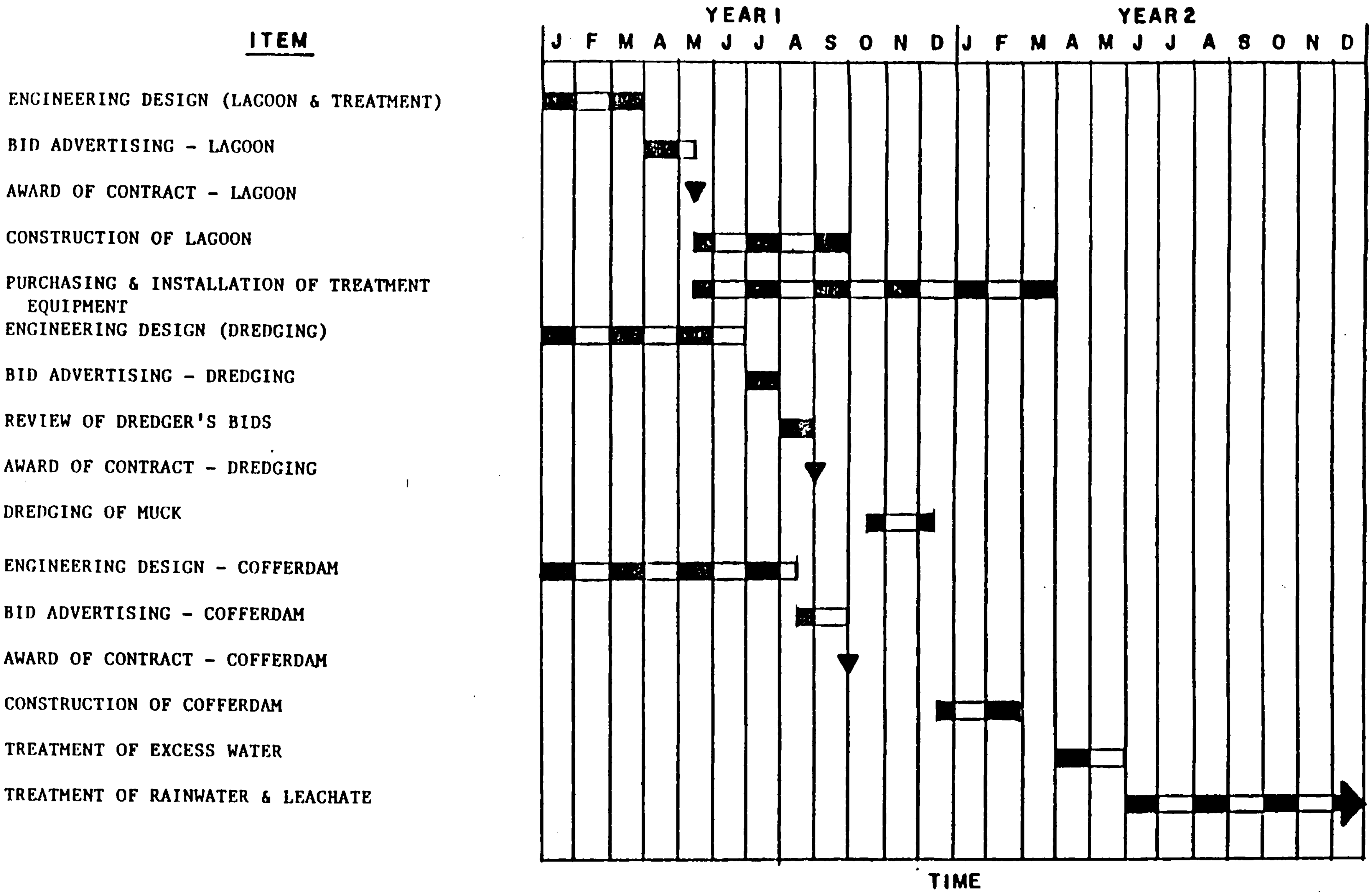


FIGURE 24 · CONSTRUCTION SEQUENCING PLAN — GREATER THAN 500 PPM

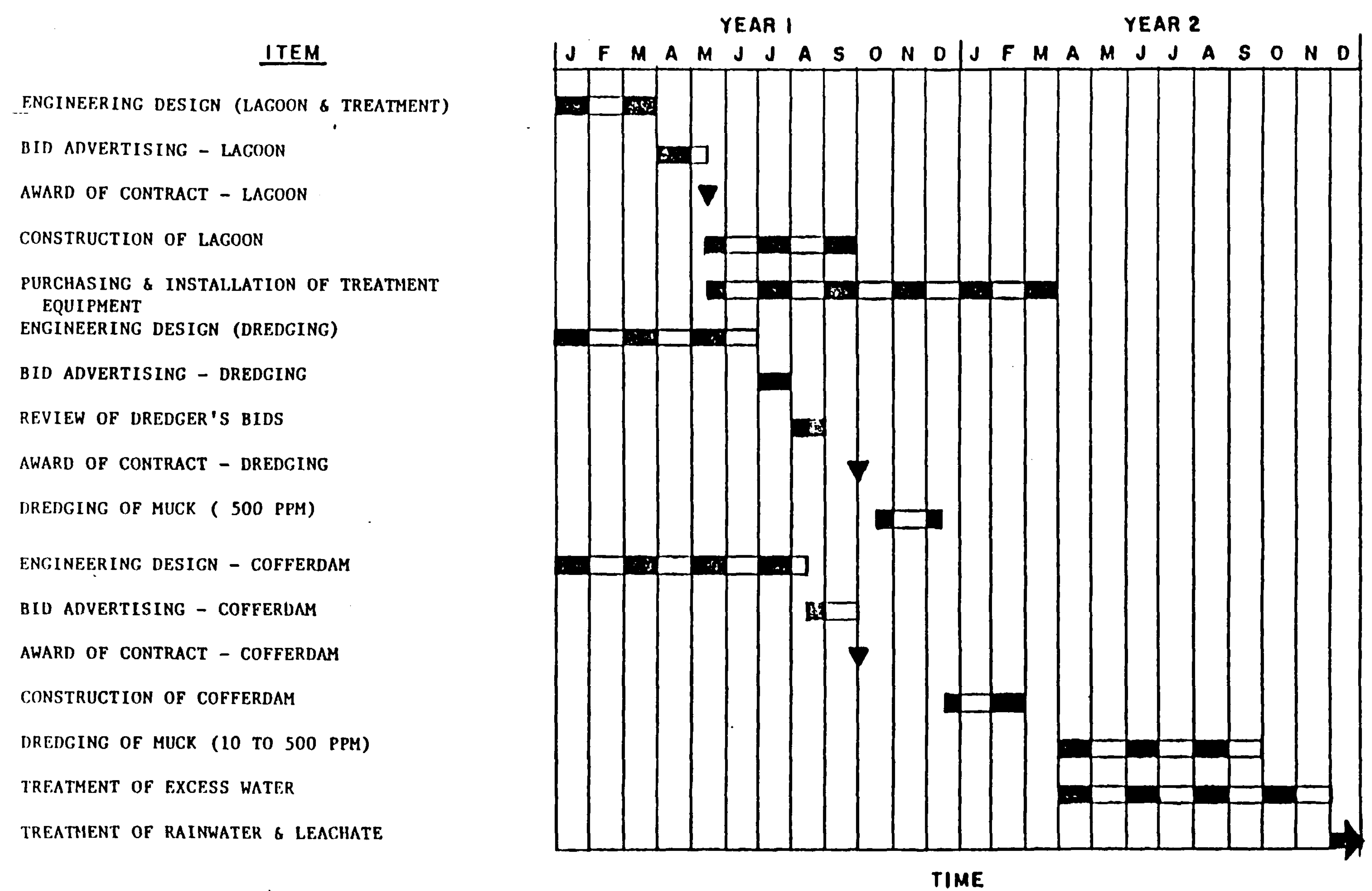


FIGURE 26 CONSTRUCTION SEQUENCING PLAN-GREATER THAN 10 PPM

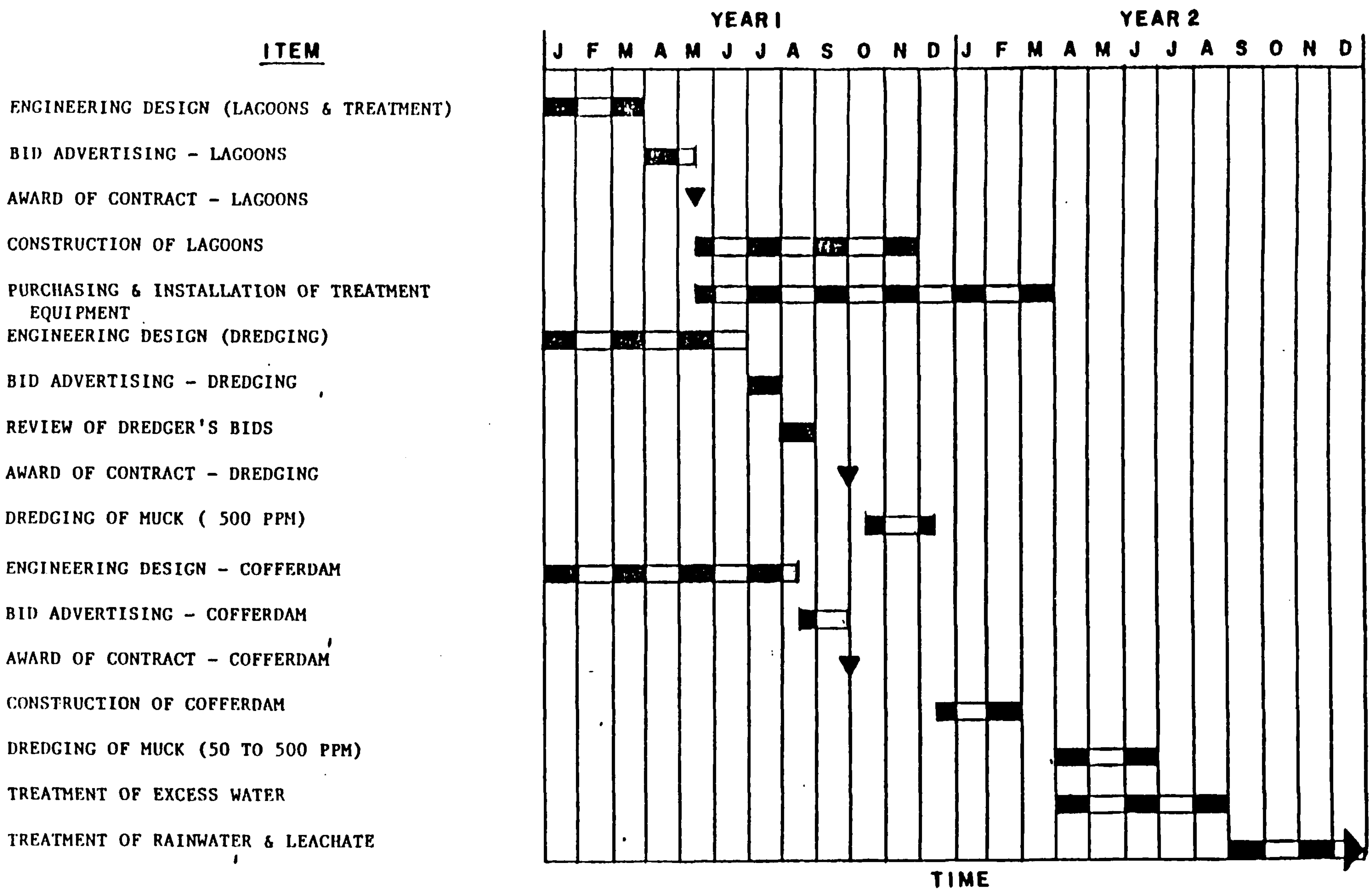


FIGURE 25 · CONSTRUCTION SEQUENCING PLAN — GREATER THAN 50PPM

9.0 ULTIMATE DISPOSAL OF RESIDUES

9.1 Recommended Final Disposal Alternative

In Section 5.0 and 6.0 Mason & Hanger recommended landfilling as the method of final disposal of contaminated soils and sediments. Incineration was considered too costly (Section 5.6 and Section 6.6), and there would be delays in constructing an incinerator and complying with permitting restrictions. Chemical and/or biological destruction methods have not yet been developed suitable for treating the large volume of contaminated materials (Section 5.1 and 6.1).

The Illinois EPA and U.S. EPA both have several requirements regarding the construction and operation of landfill facilities for PCB materials. These include monitoring wells and a leachate collection system. The Illinois EPA has suggested (not a requirement) 10 feet of clay as a liner with a maximum permeability of 10^{-8} cm/sec. The U.S. EPA is less stringent, requiring 3 feet (compacted) or 4 feet (uncompacted) minimum thickness clay having a maximum permeability of 10^{-7} cm/sec. The U.S. EPA requirement of locating 50 feet above the groundwater and away from any large body of water or river may have to be waived by the EPA regional administrator.

At this time, the CECOS landfill site northeast of Cincinnati, Ohio is the closest approved site which is licensed to receive PCB waste solids. Closer sites exist which are not licensed but can be adapted such that they could qualify as a PCB disposal site. The cost for disposal at CECOS is estimated to be \$155/cy, including a \$65/cy hauling cost for the 700 mile round trip. Hauling costs will increase as fuel costs increase.

In August 1980, Mason & Hanger subcontracted with Warzyn Engineering, Inc. to evaluate closer alternative sites which could be developed into a secure PCB disposal site. Warzyn submitted their report in December 1980 which is included as an appendix item in this report. The Warzyn report is summarized in Sections 9.2, 9.3 and 9.4.

Warzyn based their cost estimates on disposal of 367,000 cubic yards of contaminated sediments and soils. Mason & Hanger estimate 160,000 cubic yards of North Ditch area soils and sediments, 166,000 cubic yards of Waukegan Harbor muck sediment greater than 10 ppm PCB and possibly 2,000 cubic yards of Waukegan Harbor contaminated sand and clay for a total of 328,000 cubic yards. Spent carbon used in treatment, sand and the top few inches of clay used in lagoon construction, "covers" placed on exposed materials for controlling volatilization, and other extraneous material could add another 20,000 to 40,000 cubic yards to this total. The estimate of approximately 367,000 cubic yards represents the total material containing greater than 10 ppm PCB.

However, current U.S. EPA regulations (40 CFR 761) do not require that contaminated dredge spoils containing less than 50 ppm PCB be disposed in a hazardous waste landfill satisfying the requirements of 40 CFR 761.41. While materials less than 50 ppm PCB are not regulated under TSCA with respect to disposal in a hazardous waste landfill, the preamble to those regulations recognized authority of the U.S. EPA Administrator to regulate PCBs less than 50 ppm under other statutes. Thus, the necessity for removing harbor sediments containing from 10 to 50 ppm PCB is being reviewed. Mason & Hanger estimates that 121,000 cubic yards of Waukegan Harbor sediments contain less than 50 ppm PCB leaving 246,000 cubic yards or less of contaminated material greater than 50 ppm. The cost comparisons in this section are based on disposal of the entire 367,000 cubic yards of material without making a distinction between those containing greater than 50 ppm and those between 10 and 50 ppm contamination.

All of the cost information given is based on December 1980 dollars and could be expected to increase in the future.

9.2 Proposed Sites for Permanent Disposal

9.2.1 Browning-Ferris Industries (BFI) Landfill Site (Option 1)

Browning-Ferris Industries (BFI) in Zion, Illinois operates a licensed hazardous waste disposal site located approximately 12 road miles north of Waukegan Harbor. The site is not now licensed to receive PCB soils but could be prepared to satisfy U.S. EPA and Illinois EPA requirements. Site preparation would include (1) excavation of existing materials to provide volume for the PCB materials to be stored, (2) placement of granular blanket and recompacted clay liners, (3) installation of a leachate collection system, and (4) miscellaneous work. Warzyn estimated the site preparation costs at BFI to be $1,365,000 for a particular location in the western portion of the BFI facility with material placed from 10 feet below to 20 feet above the existing ground. Additional costs would be incurred by BFI for placement of the PCB laden soils, site closure, and long-term care, including monitoring.

BFI has indicated that they would accept contaminated soils and dewatered sediments at a user cost of $50 per cubic yard including transportation (200,000 cubic yard minimum). All of the contaminated material would have to be received over a relatively short time so the site could be closed. The total estimate of contaminated material containing greater than 10 ppm PCB is estimated to be approximately 367,000 cubic yards.

The total disposal cost, including a $10 per cubic yard transportation cost, is estimated to be $18,350,000 for 367,000 cubic yards.

9.2.2 Clermont Environmental Reclamation (CECOS) Williamsburg, Ohio Site (Option 2)

This site is the closest commercial site licensed to accept PCB materials. Warzyn estimates a cost to CECOS of $1,162,000 in order to prepare the site to receive PCB contaminated soils and sediments. Additional costs would be incurred to CECOS for operation and maintenance, site closure, and long term care.

CECOS indicated that the user charge for the PCB contaminated material would be $90 per cubic yard. Transportation costs would be approximately $1,300 per truckload or $65 per cubic yard based on 20 cubic yards per truckload. The total disposal cost for 367,000 cubic yards is estimated to be $56,885,000. Transportation costs can be expected to increase as fuel costs increase.

9.2.3 In-Place Secure Permanent Storage At OMC Site

9.2.3.1 Total On-Site Excavation and Disposal in OMC Parking Lot (Option 3)

In this alternative, all of the PCB-contaminated soils and dredged Waukegan Harbor sediments are disposed in a secure landfill in the OMC parking lot as discussed in Section 5.5. Warzyn has estimated the following costs:

Site Preparation	$5,852,000
Operating Costs During Filling	350,000
Site Closure	1,463,000
20 Year Care Costs	112,000
Total	$7,777,000

Operating costs include personnel and equipment, water quality monitoring, and leachate collection and treatment. They do not include trucking the contaminated material from the temporary holding lagoon to the permanent disposal site.

The almost $8 million dollar cost is less than the $20 million dollar cost at BFI and $51 million dollar cost at CECOS. However, there are disadvantages to permanent dispersal on OMC property:

1. Illinois EPA may discourage any permanent on-site disposal option.

2. There would be some stockpiling of PCB-contaminated soils until the disposal areas are ready for use.

3. Extensive site dewatering will be required.

4. The storage area is within a few hundred feet from Lake Michigan. There is insufficient data to predict the effects of erosion of Lake Michigan shore boundaries, lake levels, and the possibility of the site being under water during the next hundred or more years. It is known that Lake Michigan shoreline has historically moved due to the sandy nature of the soil and that the flood of record in 1956 flooded the Crescent DItch and Oval Lagoon on OMC property. Whoever has custody of the site will have to take care of it including protection from erosion. EPA regulations discourage hazardous waste landfill storage sites near a body of water.

9.2.3.2 <u>Leave Contamination in Crescent Ditch and Oval Lagoon; Dispose of Other Contamination in Parking Lot (Option 4)</u>

This option, not discussed in section 5.5, involves construction of a slurry cutoff wall around the perimeter of the Crescent Ditch and Oval Lagoon. This slurry cutoff wall would be approximately 2.5 feet wide and about 25 to 30 feet deep and constructed of Bentonite clay. A leachate collection system would be installed in the cutoff wall. The contamination in the Crescent Ditch and Oval Lagoon would be left in place. Monitor walls would be installed around the cutoff walls. The surface would be capped with clay. The North Ditch bypass would be installed to prevent surface water from entering this area.

Another on-site disposal facility would be constructed in the parking lot. The parking lot facility would be constructed with clay liners, slurry cutoff walls, leachate collection system, and monitoring wells but would encompass less area than the parking lot disposal facility discussed in Section 9.2.3.1. All Waukegan Harbor dredge spoils, North Ditch (east-west portion) contamination and parking lot contamination would be disposed in this facility.

Warzyn has estimated the following costs (excluding rerouting of North Ditch water and trucking contaminated soils to the parking lot site):

Site Preparation	$5,973,000
Operating Costs During Filling	350,000
Site Closure	1,544,000
20 Year Care Costs	112,000
Total	$7,979,000

This option is similar to the option discussed in 9.2.3.1, including the same disadvantages. There is one additional disadvantage; namely, there is risk involved with the long-term reliability of the slurry cutoff walls. Failure of the walls could result in excessive leachate from the area and perhaps further groundwater contamination.

This option assumes that the existing silty-clay underlying the sand will serve as an effective barrier against PCB migration. Permeability coefficients of this material are believed to be on the order of 10^{-7} cm/sec. However, PCBs have penetrated several feet into this silty-clay layer at location B32 in the Crescent Ditch, possibly aided by a peat finger into the clay. More deep borings in the Oval Lagoon and Crescent Ditch down into the silty-clay would be required to better define deep contamination.

9.2.3.3 <u>Leave Waukegan Harbor Dredge Spoils on Vacant OMC Land; North Ditch Soils Placed in Parking Lot 2. (Option 5)</u>

The alternative is the same as the option discussed in Section 9.3.2.1 and 9.3.2.2 except that the Waukegan Harbor dredge spoils are permanently left in the lagoons on OMC vacant land. The lagoons would be constructed to contain 10 feet of recompacted clay.

Sandwiched within the clay layer, at the 5 foot level, would be a one-foot thick gravel layer which would lead to an underdrain system. Any leachate permeating through the first 5 foot clay layer would be intercepted, collected, and treated for PCB removal. The lagoons would be capped with 3 feet of clay and topsoil. Monitoring wells would be installed around the lagoons.

The contaminated North Ditch soils would be placed in a storage facility located in the present OMC parking lot. Two options are possible:

Option 5A: A slurry wall is constructed around the Crescent Ditch and Oval Lagoon, and those soils are left in place. Other contaminated North Ditch soils are placed in a storage facility located in the OMC parking lot as in Section 9.2.3.2.

Option 5B: All North Ditch contaminated soils are placed in a storage facility located at the present OMC parking lot as in Section 9.2.3.2.

Warzyn has estimated these costs as follows:

	Option 5A	Option 5B
Site Preparation	$ 8,685,000	$ 7,274,000
Operating and Maintenance	357,000	357,000
Site Cosure	2,011,000	1,823,000
20 Year Care Costs	132,000	132,000
Total	$11,185,000	$ 9,586,000

The same disadvantages as discussed in Sections 9.2.3.1 and 9.2.3.2 also apply here.

9.2.3.4 Leave Waukegan Harbor Dredge Spoils on <u>Vacant OMC Land; Do Not Remove Any Of North Ditch Contamination But Construct A Slurry Wall Around Entire Area (Option 6)</u>

In this option, the Waukegan Harbor dredge spoils are permanently left in the lagoons on OMC vacant land as discussed in Section 9.2.3.3. A slurry cutoff wall is then constructed around the entire North Ditch area, and all of the North Ditch contaminated materials are left in place. Warzyn Engineering estimates the following costs:

Site Preparation	$ 7,005,000
Operation and Maintenance	250,000
Site Closure	3,488,000
20 Year Care Costs	132,000
Total	$10,875,000

These costs do not include costs for diverting the North Ditch surface water. The method is also dependent upon the long-term reliability of the slurry cutoff wall and the ability of the underlying silty-clay in retaining the PCBs. As mentioned in Section 9.2.3.1, the Illinois EPA is currently discouraging any permanent on-site disposal options.

9.2.3.5 Disposal of All Contaminated Materials in Permanent Storage on Vacant OMC Land (Option 7)

In this option, Waukegan Harbor dredge spoils are placed in the two lagoons on vacant OMC property next to Waukegan Harbor as described in Section 8.0. After the dredge spoils have been dewatered and the water removed, the North Ditch contaminated soils (estimated at 160,000 cubic yards) are placed in these lagoons. The lagoons are then capped with clay and topsoil. To adapt these lagoons for long term storage the lagoons are constructed with a ten foot clay liner; a leachate collection system is sandwiched in the liner at the 10 foot level. The lagoons are constructed above ground and will be approximately 35 feet in height. Warzyn estimates the following costs:

Site Preparation	$7,689,000
Operation and Maintenance	350,000
Site Closure Costs	1,260,000
Long Term Care Costs	112,000
Total	$9,411,000

These costs do not include loading the contaminated North Ditch soils aboard trucks and hauling them to the OMC vacant land. This would probably add another $1,000,000 to the total.

9.2.4 Other Off-Site Disposal Locations

Warzyn Engineering considered and eliminated the following sites as candidates for receiving PCB-contaminated sediments and soils:

Ottawa-Brockman site CECOS site (Ottawa, Ill)
C.I.D. landfill site (Cook Co., Ill)
Nuclear Engineering site (Sheffield, Ill)
Waste Management, Inc. site (Livingston, Alabama)
Joliet Army Ammunition Plant (Joliet, Ill)

9.3 Evaluation of Sites

Economics favor on-site disposal on OMC property over off-site disposal. The cost for on-site disposal is roughly around $10 million compared with almost $20 million for the BFI site in Zion, Illinois. Neither the BFI site or OMC property site is permitted to receive PCB contaminated material. The closest site permitted to receive PCB contaminated material is CECOS near Williamsburg, Ohio, at a disposal cost of about $57 million. These costs are based on disposal of 367,000 cubic yards of contaminated material.

Table 4 presents costs for six on-site disposal alternatives as estimated by Warzyn Engineering. The Warzyn costs do not include any escalation, contingency, permitting costs, placement of contaminated material into the disposal site, diversion of North Ditch surface water, etc. Therefore, Warzyn's costs cannot be directly added to costs developed in Sections 7 and 8 to arrive at an overall project cost. Mason and Hanger suggests adding the following costs to each of the options to cover a 20 percent contingency, placement of material into site, etc.:

On-Site Option	Warzyn Estimate	Additional Costs	Total Disposal Cost
3	$ 7,777,000	$3,757,000	$11,534,000
4	7,979,000	3,523,000	11,502,000
5A	11,185,000	2,983,000	14,574,000
5B	9,586,000	2,967,000	12,553,000
6	10,875,000	4,575,000	15,450,000
7	9,411,000	3,089,000	12,500,000

Option 6 include a 20 percent contingency and costs for construction of the North Ditch bypass.

The above estimated total disposal costs are in addition to the costs for the Waukegan Harbor project described in Section 8.0. The North Ditch excavation project costs described in Section 7.0 must also be added to the on-site disposal cost for options 3, 5A, and 7 with the exception of deleting the parking lot restoration item (already accounted for by Warzyn in their estimate). Only some of the costs listed in section 7.0 would be added to options 4 and 5B to arrive at a total project cost as they incorporate concepts of on-site containment rather than excavation. To arrive at the total project cost for Option 6 only the Waukegan Harbor cost in Section 8 need be added.

If permanent disposal on OMC property is declared a viable option then of all the on-site disposal alternatives, both Warzyn and Mason & Hanger would select alternative 3 (disposal of all contaminated material including dredged Waukegan Harbor sediments in a secure landfill in the OMC parking lot) over the other alternative for the following reasons:

1. All of the contamination will be in one place simplifying maintenance.

2. All of the contamination will be in sites lined with clay and not be dependent upon the underlying silt clay layer and slurry walls to retain the PCBs.

3. Alternatives 5, 6 and 7 would severely limit the end use of the OMC land adjacent to Waukegan Harbor whereas OMC can still use the land as a parking lot after PCB-contaminated material is sealed within.

Alternative 7 (disposal of all contaminated material in lagoons on OMC vacant land adjacent to Waukegan Harbor) emerges as a second choice, but end use of this land would be severely limited. The mound containing the PCBs would also be conspicuous to the public using Waukegan Harbor.

TABLE 4

COMPARISON OF ON-SITE DISPOSAL ALTERNATIVES
RECOMMENDED BY WARZYN ENGINEERING

OPTION	3	4	5A	5B	6	7
Site Preparation	$5,852,000	$5,973,000	$ 8,685,000	$5,209,000	$ 7,005,000	$7,689,000
Operation & Maintenance	350,000	350,000	357,000	357,000	250,000	350,000
Site Closure	1,463,000	1,544,000	2,011,000	1,823,000	3,488,000	1,250,000
20 Year Care	112,000	112,000	132,000	132,000	132,000	112,000
TOTALS	$7,777,000	$7,979,000	$11,185,000	$9,586,000	$10,875,000	$9,411,000

Options are identified in the text.

The costs do not include (1) hauling and placement of the contaminated material in the disposal vault (2) diversion of North Ditch water, or (3) any contingency items, overhead, or profit.

Methods of calculation are detailed in the Warzyn report. (See Appendix)

Several variations of these alternatives are possible. For example, Waukegan Harbor dredge sediments containing less than 50 ppm PCB (121,000 cubic yards) might be disposed in the OMC parking lot or in a nearby landfill. The material containing more than 50 ppm PCB (246,000 cubic yards) would be disposed in a hazardous waste landfill satisfying the requirements of 40 CFR 761.41.

The decision as to whether to select on-site or off-site disposal is influenced by factors other than economics. These factors include:

1. Permission of OMC management.
2. Acceptability of on-site disposal to Illinois EPA and U.S. EPA.
3. Relative quickness of licensing of either the BFI site or on-site options for receiving PCBs (on-site licensing would be slower).
4. Potential local opposition to on-site and off-site disposal.

9.4 Environmental Concerns of On-Site Disposal

Despite favorable economics, there are several environmental concerns for disposal on OMC property.

1. On site disposal is within a few hundred feet from Lake Michigan.
2. Ground water levels are within a few feet from the surface.
3. The site would have to be permanently maintained and monitored by OMC or whoever will own the land.

The North Ditch (including the Crescent Lagoon, Oval Lagoon, and the E-W portions of North Ditch) flooded during the storm of record in 1956. If on-site disposal is to be considered, the site must consider the elevation of a 100 year flood.

The owners of the land will have to maintain the integrity of the site if the Lake Michigan shoreline should change during the next several hundred years (shorelines can erode away or the Lake may recede or Lake levels increase). Arrangements will have to be made for continuous care of the land.

An environmental argument favoring on-site disposal is that the OMC site is already contaminated with PCBs. The secure on-site landfill would permit collection and confinement of the worst of the contamination. There would still be low level contamination which would remain outside the on-site landfill. The groundwater already contains a few ppb of PCB.

Additional investigations and/or studies of the geology of the area and of PCB migration in groundwater are needed before final recommendations can be given concerning on-site disposal. Dr. Douglas Cherkauer, University of Wisconsin consultant under contract to U.S. EPA to study PCB migration in groundwater at OMC, has not yet published his findings.

9.5 Secure Landfill Liner

Warzyn Engineering, Inc., in their analysis of on-site and off-site disposal alternatives, recommended that the PCB-contaminated material rest on top of a gravel or sand sublayer containing a leachate collection system. Underlying this sublayer is 5 feet of recompacted clay (recompacted to give 10^{-8} cm/sec. permeability coefficient). Another leachate collection system embedded in a 1 foot granular layer is beneath this 5 feet of clay; a membrane liner is also placed in the 5 feet of clay. Under this second leachate collection system are three or more feet of recompacted clay. When the site is filled, the contaminated material is capped with 3 feet of clay with a membrane liner sandwiched inside. Soil is placed on top of the clay, which is seeded, fertilized, and mulched.

Two samples of silty-clay collected in July 1980 from Waukegan Harbor (under the muck and sand sediments) were reported by Warzyn to have a permeability coefficient of 10^{-7} cm/sec. Some of the clay at the BFI site has a 10^{-8} cm/sec. permeability. Warzyn reports that there is an ample supply of clays in Wisconsin which at 90 percent compaction should have a permeability coefficient of 10^{-8} cm/sec.

This report refers to the underlying clay in Waukegan Harbor or North Ditch as "silty-clay". Warzyn Engineering reports that this clay is not homogeneous, and a more correct description would be stiff to very stiff clay sediments ranging from "silt" to "clayey silt", to "silty clay", with occulsions of sand and gravel. The clay boundary classifications range from ML to ML-CL to CL soils based on the Atterberg Limit of Classification.

Information obtained from the limited core borings indicate that the underlying silty clay at OMC and Waukegan Harbor contains occlusions of gravel, sand and peat. These occlusions can provide pathways for PCB penetration. PCB penetration has been found in the silty-clay under OMC outfalls to North Ditch and Waukegan Harbor. For this reason, Mason and Hanger at this time is not recommending any of the alternatives which depend on the underlying silty clay to contain the more concentrated PCB material. However, these alternatives are more acceptable environmentally than no action at all. The available core borings suggest that underlying silty clay can stop low level PCB contamination (less than 500 ppm) adsorbed on sediments but not liquid or free PCB. More study is needed if any of the permanent inplace storage alternatives are to be considered further.

Other factors are important than specifying a clay liner thickness or permeability coefficient. During construction of any liners, the clay material should be spread and compacted in thin layers (say 6 inches) to eliminate occlusions of air and water. Precautions must be taken to keep the clay wet since drying clay will shrink and crack. A three foot clay liner compacted to give a uniform 10^{-8} cm/sec. permeability coefficient can provide a more secure landfill than a 10 foot clay liner which has not been satisfactorily compacted in layers, even though the raw clay material has the same permability coefficient in both situations.

Warzyn Engineering has suggested the use of a membrane liner sandwiched in the storage basin clay liner. Hypalon liners are available having a permeability coefficient exceeding 10^{-12} cm/sec. Nothing is known on the stability of such liners after decades or centuries of use, and therefore synthetic liners should not be used in place of clay. Their use in addition to clay liners, as proposed by Warzyn, may be unnecessary.

Sample Calculation for Penetration of PCB Through A Clay Liner

The following example is included only to indicate a method for calculating penetration of PCBs thru a clay liner. The following are the assumptions used in this sample calculation:

Thickness of Clay Liner	3 ft.
Permeability of Clay	10^{-8} cm/sec
Head of Water	15 ft.
Porosity of clay	0.5
Concentration of PCB in Water	100 ppb
Area of Landfill	660,000 sq. ft.
Cubic Yards of Contaminated Material	367,000 cu. yd.

The velocity of the pentrations of water through the liner is:

$$V = KG/P$$

Where: V = Velocity of penetration in ft/day
G = Hydraulic gradient, e.i. Head of Water (H)/liner thickness (ft)
K = Permeability coefficient cm/sec
P = porosity

Calculate V:

$$V = 10^{-8}\ \frac{cm}{sec} \times \frac{1}{30.48}\ \frac{ft}{cm} \times 86{,}400\ \frac{sec}{day} \times \frac{15\ ft}{3\ ft} \times \frac{1}{0.5}$$

$$V = 2.84 \times 10^{-4}\ ft/day$$

Calculate time to penetrate 3 ft. of liner:

$$Time = 3\ ft \times \frac{1}{2.84 \times 10^{-4}}\ \frac{day}{ft} \times \frac{1\ year}{365\ days}$$

Calculate volume of water penetrating liner bottom:

$$\text{Volume} = \text{Permeability } \frac{\text{ft.}}{\text{day}} \times \frac{\text{Head of Water (ft)}}{\text{Thickness of Liner (ft)}} \times \text{Area ft}^2$$

$$= \frac{2.84 \times 10^{-5}\text{ ft}}{\text{day}} \times \frac{15\text{ ft}}{3\text{ ft}} \times 660{,}000\text{ ft}^2 \times 365\ \frac{\text{day}}{\text{yr}}$$

$$= 3{,}420\text{ ft}^3/\text{yr.}$$

Calculate amount of PCBs penetrating liner after steady state conditions are reached:

$$\text{Amount} = \text{volume } \frac{\text{ft}^3}{\text{yr}} \times \text{concentration, ppm} \times 62.5\ \frac{\text{lbs}}{\text{ft}}$$

$$\text{Amount} = 3{,}420 \times 100 \times 10^{-9} \times 62.5$$

$$\text{Amount} = 0.02\text{ lb/yr PCB}$$

In the above example it is assumed that only water penetrates the clay, the water is saturated and that steady state conditions exist. In reality some of the PCBs will be absorbed in the clay, and it will be many years before the clay becomes saturated. Only after the conditions occur will the 0.02 lb/yr of PCBs be transferred through the clay liner to the underlying leachate collection where it would be collected. As a matter of reference, a 10 foot thick clay liner would theoretically allow the passage of 0.006 lbs of PCBs per year. The calcualtion can be easily reworked for a 10^{-7} cm/sec permeability coefficient.

For comparison purposes, estimates of PCB migration in groundwater to Lake Michigan should be obtained for (1) current statis and (2) situations where all contaminated material greater than 50 ppm (or other level set by the EPA) is removed. If the PCBs left in groundwater (pounds per year to Lake Michigan) after removal of contaminated material are much higher compared with the 0.02 lbs./year PCB migration through 3 feet of clay, then there is good argument for using 3 feet of clay in an on-site storage system. If an off-site storage is used, background PCB levels should be obtained. If the off-site disposal area is clean, additional study of the off-site disposal area will be needed including proximity to wells, etc.

Mason & Hanger is of the opinion that some additional study is needed before a firm justification can be given for a particular liner construction. The site location will influence the design of the liner system.

9.6 Recommended Site For Disposal

Mason & Hanger recommends that both the BFI site and on-site locations be further considered for permanent disposal.

On-site disposal is more cost effective than the BFI site, and either alternative is more cost effective than the CECOS site in Williamsburg, Ohio. Generally, when alternatives are considered, Mason & Hanger will recommend the least costly alternative unless these are overwhelming en-vironmental adversities that would indicate approval by the regulatory agencies cannot be obtained.

OMC's position on permanent on-site disposal and long-term care commitments should be solicited. If OMC reacts favorably to on-site disposal, the applicant should initiate Illinois EPA review procedures. Illinois EPA will likely request detailed geological information as well as a project description and later render a tentative opinion. An unfavorable report does not necessarily imply that the site cannot be changed to correct the limitations. If the Illinois EPA issues a favorable report or if the deficiencies can be corrected, then OMC (applicant) should request a permit from the Illinois EPA for a refuse disposal facility.

If OMC refuses on-site permanent disposal or if the Illinois EPA cannot issue approval, then application should be made for the BFI site (procedures specified in State of Illinois Environmental Protection Act, Public Act 76-2429).

If neither alternative is acceptable nor can be made to be acceptable, the CECOS site is the only other alternative not eliminated in the report and should be considered. A more detailed comparison with landfilling vs. incineration would, therefore, be recommended as disposal costs would exceed $100 per cubic yard and incineration might be economi-cally competitive. Incineration costs would depend greatly on regulatory requirements for the incinerator, operation conditions and disposal of incinerated sediments and soils.

10.0 SUMMARY OF COSTS

10.1 North Ditch Area

Removal of PCB-contaminated materials in this area should be performed in increments. The North Ditch bypass should be constructed first; the excavation of the other three areas should follow. These are: (1) the Crescent Ditch, (2) the Oval Lagoon and (3) the Parking Lot contaminated area. The bypass construction is called Phase I and excavation of the other three areas is called Phase II. The summary of costs set forth below reflect the work being performed in phases. The costs reflected are detailed under Section 7.7 of this report and are based on December 1980 costs. Costs for ultimate disposal in an approved site are not included.

Phase I	Estimated Construction Cost	$ 2,004,000
	Allowance for Contingency	401,000
	Total Phase I	$ 2,405,000
Phase II		
	Crescent Ditch	
	Estimated Construction Cost	$ 2,799,000
	Allowance for Contingency	560,000
	Sub Total	$ 3,359,000
	Oval Lagoon	
	Estimated Construction Cost	$ 686,000
	Allowance for Contingency	137,000
	Sub Total	$ 823,000
	Parking Lot	
	Estimated Construction Cost	$ 3,875,000
	Allowance for Contingency	775,000
	Sub Total	$ 4,650,000
	Total Phase II	$ 8,832,000
	Total Phase I	$ 2,405,000
TOTAL - NORTH DITCH		$11,237,000

10.2 Waukegan Harbor

The costs associated with these alternatives for removal of the contaminated Harbor sediments to different degrees of PCB concentration are detailed in Sections 8.8 of this report.

The estimated construction cost for each of the three plans is predicated on receiving competitive bids from General Contractors who would bid from a set of approved drawings and specifications. There are many indeterminate cost factors involved, and a significant spread between several contractor's bids can be expected. The dredging costs may well vary by multiples greater than two. The cost of dike construction is also subject to variation, but less variation is expected compared to dredging costs. The reason is, earthwork of this nature can be estimated differently by different contractors having identical equipment.

A description of each of the alternatives follows:

Plan 1 includes costs for dredging of 7300 cubic yards of sediments containing greater than 500 ppm PCB from the harbor and storing them in a temporary lagoon. Excess water from the dredging operation after separation of the solids is treated to remove PCBs before discharge. The work estimated costs includes (1) dredging; (2) construction of a lagoon to hold 55,000 cubic yards of slurry; (3) construction and operation of a treatment facility to treat excess dredging waters initially and rainwater and leachate over a two-year operating period. Excavation of the deep contaminated sediments in Slip #3 is included.

Plan 2 includes dredging all of the sediments containing more than 50 ppm of PCB and storing them in two - 55,000 cubic yard lagoons. These sediments are located in all of Slip # 3 plus a portion of the harbor between Slip #3 and Slip #1. The two 55,000 cubic yard lagoons will not have sufficient capacity to hold the expected 150,000 cubic yards of slurry to be pumped from the dredging operation. Therefore, the cost of this alternative also includes a large treatment facility. The costs includes construction and two years of monitoring, and 6 months of treatment of lagoon effluent. Excavation of the deep contaminated sediments in Slip #3 is included.

Plan 3 involves the dredging of all the contaminated sediments in the harbor containing greater than 10 ppm of PCB. The estimated quantity of sediments to be pumped and stored in the two lagoons is 166,000 cubic yards. This requires the enlargement of the lagoon dikes to hold 150,000 cubic yards of slurry each. The quantities of earth required to build the dikes with a slop of 3:1 is approximately 3-1/2 times that of the dikes required for the storage of sediment contaminated to greater than 50 ppm. The cost of the lagoons increases by a multiple of 2.27, and the entire operation of dredging and treatment will require increased rental time for treatment equipment from 6 months to about 8 months. There is a several month safety factor on this rental time. Excavation of the deep contaminated sediments in Slip #3 is included.

A summary of the estimated cost of the alternative plans for Waukegan Harbor cleanup is:

Plan	Removal of Contamination Muck	Removal of Deep Contamination in Slip #3	20 percent Contingency	Total
1.	$1,916,000	$ 389,000	$ 461,000	$2,766,000
2.	$3,843,000	$ 389,000	$ 847,000	$5,079,000
3.	$6,619,000	$ 389,000	$1,402,000	$8,410,000

10.3 Ultimate Disposal Costs

Ultimate disposal costs are presented in Section 9.0.

11.0 RECOMMENDATIONS

11.1 Applicable to the North Ditch

1. The contaminated soils and sediments in the North Ditch and surrounding areas should be removed by excavation.

2. The excavated contaminated materials should be placed in a secure landfill constructed in accordance with applicable governmental regulations.

3. Economics favor location of the secure landfill in the parking lot of the Outboard Marine Corporation property south of the North Ditch. Alternative locations on OMC property may be acceptable. There are some environmental considerations with this location, including proximity to Lake Michigan, which are discussed in Section 9.0.

4. If the OMC site(s) is determined to be unacceptable by OMC and the licensing governmental agencies, then the contaminated materials should be taken to the Browning Ferris Industries' (BFI) hazardous waste landfill in Zion, Illinois, provided the BFI site can be upgraded to receive PCB contaminated wastes, which it is not presently permitted to do.

5. If neither the OMC site nor BFI site in Zion, Illinois are acceptable, then the contaminated materials should be taken to the CECOS hazardous waste landfill in Williamsburg, Ohio since this site is presently permitted to receive PCB contaminated wastes. Some upgrading of this landfill should be performed before it receives the contaminated materials.

6. The work in the North Ditch should be performed in two phases. The first phase should consist of a bypass being constructed around the most highly contaminated areas of the North Ditch. The second phase should consist of excavation in a dewatered condition the remaining contaminated sediments. This should be accomplished by using wellpointing and slurry walls.

7. Measures should be taken to minimize volatilization of PCBs from the contaminated sediments. A study should be immediately undertaken to examine this problem.

8. Incineration should be examined more closely if the materials are prevented by licensing governmental agencies from being taken to any hazardous waste landfills or if landfilling costs are much above $100 per cubic yard.

9. Additional sampling to further delineate the extent of contamination should be performed, particularly in areas of high contamination, to more clearly define, thus minimize, the quantity of soils and sediments which need to be excavated.

11.2 Applicable to Waukegan Harbor

1. The contaminated muck sediments in Waukegan Harbor should be removed by dredging (hydraulic or pneumatic dredges).

2. The slurry from the dredging operation should be pumped to a temporary storage lagoon(s) for removal of excess water by sedimentation.

3. One, or two, temporary storage lagoons should be constructed on the presently-vacant land owned by Outboard Marine Corporation adjacent to Waukegan Harbor. The number of lagoons would depend upon the extent of the cleanup in the harbor.

4. The temporary storage lagoons should be built in accordance with applicable governmental regulations for the disposal of hazardous wastes, with consideration given to the temporary (less than 5 years) period of time planned for containment.

5. The excess water from the lagoon should be treated with a coagulant, discharged to a sedimentation basin for removal of coagulated solids, pumped through a sand filter to remove fine particles, pumped through a carbon filter to remove soluble PCBs, stored in a clear well for verification of PCB removal by sampling and analysis, and discharged back to Waukegan Harbor. The discharged water should contain less than 1 ppb PCB.

6. Spread of roiled sediments caused by dredging, particularly in Slip #3, should be minimized by installation of at least two silt curtains at the boundary of the slip and by selection of a dredging operation capable of performing with minimum turbidity. After dredging the most contaminated portions of Slip #3, addition of polymers and possibly powdered carbon at that location should be considered to assist turbidity and soluble PCB removal.

7. The contaminated sand and clay sediments underlying the muck in Slip #3 near the OMC outfall should be removed by excavation after the muck is removed by dredging. A slurry wall-coffer dam arrangement should be built just beyond the perimeter of the contaminated sand and clay. The water inside the slurry wall-coffer dam should be pumped to the lagoon, and the sand and clay should be excavated dry.

8. The most contaminated sediments from the upper part of Slip #3 should be stored in a separate compartment of the lagoon. After these sediments are dewatered, they should be covered with materials such as organic sludge, plastic sheeting, and /or soil to minimize volatilization of PCBs into the air. A study should be immediately undertaken to examine the volatilization problem.

9. A continuing program for monitoring the lagoons should be established. Leachate, rain water, and monitoring wellwater collected from the lagoon should be treated with filtration and carbon filtration to remove suspended solids and soluble PCBs before discharge.

10. The dewatered sediments should ultimately be removed to a secure landfill constructed in accordance with applicable governmental regulations.

11. Economics favor location of the secure landfill in the parking lot of the Outboard Marine Corporation property. Alternative locations on OMC property may be acceptable. There are some environmental considerations with this location, including proximity to Lake Michigan, which are discussed in Section 9.0.

12. If the OMC site(s) are not acceptable to OMC and governmental agencies, then the contaminated materials should be taken to the Browning Ferris Industry hazardous waste landfill in Zion, Illinois, based on sites which can be upgraded to receive PCB-contaminated wastes but which are not presently permitted to do so.

13. If neither the OMC site(s) or BFI site can be made acceptable, then the contaminated materials should be taken to the CECOS hazardous waste landfill in Williamsburg, Ohio.

14. Incineration as an alternative should be more closely examined if the materials are prevented by licensing governmental agencies from being taken to any hazardous waste landfill or if landfilling becomes very expensive (much over $100 per cubic yard).

12. APPENDICES

The following appendices are included under separate cover:

1. Waukegan Harbor Contamination Data from Various Sources

2. Preliminary Discussion of Environmental Considerations Resulting From Failure to Remove PCB Contamination from North Ditch and Waukegan Harbor by Mason & Hanger

3. Waukegan Harbor Dredging and Dredge Spoil Treatment Parameters Developed From Bench Scale Laboratory Treatment Tests by Mason & Hanger

4. Final Site Selection and Evaluation for a Hazardous Waste Disposal Site C 9400 by Warzyn Engineering Co., Inc.

POCKET INSERT 1:

FINAL SITE SELECTION AND EVALUATION FOR A HAZARDOUS WASTE DISPOSAL SITE

POCKET INSERT 2:

NORTH DITCH CONTAMINATION

POCKET INSERT 3:

MUCK SEDIMENT CONTOURS AND THICKNESS AND HARBOR SAMPLING POINTS